TROPICAL AGRICULTURE

THE JOURNAL OF THE IMPERIAL COLLEGE OF TROPICAL AGRICULTURE

VOL. XXX JULY–SEPT., 1953 NOS. 7–9

Acting Editor
M. H. BREESE

TROPICAL AGRICULTURE is published by the Imperial College of Tropical Agriculture, St. Augustine, Trinidad, British West Indies. Subscription rates can be obtained from the Head of the Library and Publications Department at the above address, or from the Secretary of the College, 40, Norfolk Street, Strand, London, W.C.2, England. Authoritative articles for publication should be submitted to the Editor for consideration. Cables: Stomata. Phone: St. Augustine, 94419. *It is understood that opinions expressed or recommendations made in signed articles or in articles of which the source is named are those of the author and do not necessarily represent the policy or opinion of the College Authorities.* Increasing numbers of inquiries are being received from the various parts of the tropics which can be answered only by persons possessed of an intimate knowledge of local conditions. Enquirers should first satisfy themselves that their local Department of Agriculture is not able to supply them with the desired information before communicating with us. Correspondence is invited on all other matters pertaining to tropical agriculture and related subjects.

EDITORIAL

'TROPICAL AGRICULTURE'—EDITORIAL, PUBLICATION AND SUBSCRIPTION CHANGES

WITH the first issue of 1954, ' Tropical Agriculture ' will appear in a new guise. It will be published in England on behalf of the College by Butterworths Scientific Publications. Issues will appear quarterly on the 15th of January, April, July and October.

Publication in the United Kingdom will make possible improvements in the format (though the page size will remain almost the same as at present), in typography and illustrations, in distribution by the world-wide system available through Messrs. Butterworths, and in speedier receipt of articles from many parts of the tropics. The difficulties and delays in publication which have unavoidably occurred and for which we have sometimes had to apologise to readers will now, we hope, be a thing of the past.

' Tropical Agriculture ' will continue to be the Journal of the Imperial College of Tropical Agriculture. This will be ensured by the fact that the two editors will be persons associated with the College, and one of them resident at the College. Articles published will continue to cover the work of

the College, but it is intended that they will also in the future give a wider picture of developments in scientific agriculture in other parts of the tropics.

At the same time as these changes, there will be a long overdue rise in subscription rates to cover modern publishing costs. It is hoped however that the Journal in its new form will provide subscribers with good value for money at present-day standards. The subscription will be £2 per year, or 10/- for each quarterly issue, post free.

Articles for publication from the College and the Caribbean area should be submitted through the College Editor, who will at present be the Principal (Dr. G. A. C. Herklots). Other contributions should be sent to the General Editor, Mr. G. B. Masefield, A.I.C.T.A., Department of Agriculture, Oxford University, Parks Road, Oxford, England. Subscriptions and advertising matter should be addressed to Butterworths Scientific Publications, 88, Kingsway, London, W.C. 2.

ANNOUNCEMENT

THE Commonwealth Bureau of Pastures and Field Crops, which has been attached to the Welsh Plant Breeding Station, Aberystwyth, for the past 24 years was transferred to Hurley, Berkshire, in August 1953 and will now be attached to the new Grassland Research Station, of which Dr. Wm. Davies is Director.

This Bureau, one of the 10 Commonwealth Agricultural Bureaux was founded at Aberystwyth in 1929, its first Consultant Director being Professor, now Sir George, Stapledon. For the first 20 years of its existence the Bureau was in charge of Dr. R. O. Whyte who was succeeded as Director in 1949 by Mr. A. G. G. Hill, formerly Director of the East African Agricultural Research Institute, Amani. The Bureau issues the well-known quarterly abstract journals *Herbage Abstracts* and *Field Crop Abstracts*, in addition to its other activities.

REVIEW ARTICLES AND BOOK REVIEWS

GENERAL AGRICULTURE AND HORTICULTURE

FARM ANIMALS—THEIR BREEDING, GROWTH AND INHERITANCE

By JOHN HAMMOND. 2nd Edition. *Edward Arnold & Co., London*, 1952. *Pp.* vi + 266. *Illustrated. Price* 18 *shillings.*

Born on a Norfolk farm John Hammond carried with him into the laboratory a background of practical animal husbandry which through the years has imparted a flavour to his extensive research programme in the field of animal genetics and physiology. Although an acknowledged scientist he has never lost the respect of the British Farming community, not only because of his early associations, but also because he is one of the few scientists who are able to put across to the farmer the practical implications of their findings rather than burden the practical mind with the great detail of scientific investigations.

This great asset is evident in "Farm Animals" which is based, as the preface states, upon two series of lectures given to inform the student and animal breeder about recent scientific research and its application to animal production.

The book emphasises the great amount of research that has been undertaken in this field at Cambridge over "the Hammond decade". The abundant findings of this one school are woven together with those of many others into what must surely be one of the most interesting and readable textbooks of any faculty.

The first edition of "Farm Animals" has probably done more than any other volume to emphasise the important economic implications of animal genetics and physiology. Appearing as it did in 1940, amidst wartime restrictions, the first edition quickly ran through several printings and was much sought after by both the student and teacher alike since it brought together such a great mass of information which was previously scattered in a great variety of journals published in many different places.

Dr. Hammond in writing "Farm Animals" has created an excellently illustrated textbook incorporating many easily understood graphs, histograms, diagrams and photographs, all of which have been woven into a most readable text. This has enabled the book to be understood by that fortunately ever-decreasing group of so-called husbandmen who so greatly distrust the application of science to animal production.

The doyen of Animal Physiologists has himself now brought up to date his classic work, in the light of the enormous amount of research which has been undertaken in many centres in the field of animal physiology and genetics during the past twelve years. Dr. Hammond has revised the text and reference list besides including more pictorial matter. The revised list of references at the end of each chapter ably serves to allay the thirst of those readers who have become sufficiently enticed by the excellence of the subject matter and wish to know more.—J.R.H.

THE SOUTH AFRICAN SUGAR YEAR BOOK 1951–52

Compiled and issued by the staff of the South African Sugar Journal, Durban. Pp. 288. *Price* 5 *shillings.*

This number, the twenty-second published, maintains the high standard set by the publishers and printers for many years.

This year book contains all the usual data which have made it so important a work of reference on the South African Sugar Industry.

A new departure, since our last review, was started in the previous year and is contained in this number. It is a section dealing with the principal sugar milling enterprises outside the Union of South Africa. The territories in question include Angola, Belgian Congo, East Africa, Mauritius, Mozambique and Southern Rhodesia.

For anyone desiring to obtain reliable information on the South African Sugar Industry regarding the outlook and policy of the various Associations, brief summaries of the production and consumption statistics, prices of cane and sugar, railway carriage rates and research results, the South African Sugar Year Book is an invaluable guide.—R.D.E.Y.

GARDENS OF THE ANTILLES

By JOHN V. WATKINS. *University of Florida Press,* 1952. *Pp.* ix+244. *Illustrated. With check list and index. Price* $3.75 (U.S.).

Professor Watkins' account of his tours in the Caribbean is both entertaining and instructive. Entertaining in that he imbues an infectious enthusiasm into his writing. Instructive mainly in that it sheds light upon the activities of that gregarious strain of humanity, the American tourist, specimens of which now reach these shores in ever increasing numbers, clad in strange attire, even stranger hats, dark glasses and always—well, nearly always—two cameras.

Professor Watkins patently played the role of Tourist as we imagine it should be played, even to the tune of eight hundred photographs !, (though only five of these appear in the text) but with a novel addition—he had a purpose for his tours. This was to visit as many established Botanic Gardens and nurseries, whether privately owned or Government managed, in as many islands as possible within the time at his disposal, and to see for himself plants long known either by name only or as conservatory specimens.

Addressed primarily to students of horticulture and to gardeners—gardeners, Professor Watkins please, not "plantsmen"—professional and amateur, and more particularly to those who have the wherewithal to satisfy an urge for travel in these parts, this book could well be read by those other fortunates who come here for no other apparent reason than to be able to say "we have been there" and quickly go their way.—J.W.

PLANT PHYSIOLOGY

THE PHYSIOLOGY OF SEEDS

By W. CROCKER and L. V. BARTON. *Waltham, Mass., Chronica Botanica Co.; London, W.C.2., Wm. Dawson & Sons, Ltd.*, 1953. *Pp.* xviii + 267. *Price* $6.50 (U.S.).

Here is the most authoritative and up-to-date book on the physiology of seeds in its various aspects that has yet become available. The authors, long engaged on, and associated with the many problems of seeds and seed technology, and well known in print, have succeeded in most commendable measure in attaining their aims, viz., ". . . . . an attempt to give a broad coverage of our present knowledge on seeds and germination in a volume of moderate size."

Yet the broadness of the scope of this book has in no way led to superficial treatment nor is it merely a collection of the results of various lines of investigation, but a well set-out, carefully collated and reasoned review of the many subjects under discussion.

While some readers will be disappointed that certain aspects are not touched upon—for example, no mention is made of the consequences of hybridization and inbreeding on seed size and vigour—the authors have themselves acknowledged the impossibility, within their self-imposed limits, of dealing with every problem connected with seeds.

That broad coverage has been achieved is amply indicated by the chapter heads, ranging as they do from the anatomy of seeds, through seed production, chemical composition, water relations, respiration, germination factors, dormancy, storage, &c., &c. to the seed transmission of diseases.

That detail has not been sacrificed is indicated by the section and subsection heads of, for example, Chapter VIII—Factors affecting germination II. Gases, inorganic salts, organic substances, growth substances, colchicine, penicillin, DDT, pelleting, heavy water, pressure, X-rays, cathode rays, uranium compounds, radium and atomic rays. A very full contents list, having page references even for chapter subsection heads, makes the task of referring to any specified topic extremely simple.

References are given at the end of each chapter, a practice which is very convenient for the reader but leads, inevitably, to some duplication. Over 1,100 citations are made in all.

The book is complete with both subject and author indexes.

Published as Volume 29 of a New Series of Plant Science Books and edited by Dr. Verdoorn, the production of this book is well up to the high standard we have come to expect from the Chronica Botanica Co.—J.W.

FIELD EXPERIMENTATION

FIELD EXPERIMENTATION WITH FRUIT TREES AND OTHER PERENNIAL PLANTS

By S. C. PEARCE. *Technical Communication No. 23 of the Commonwealth Bureau of Horticulture and Plantation Crops, East Malling, Maidstone, Kent, England. Commonwealth Agricultural Bureaux.* 1953. *Pp.* x + 131. *Price* 10 *shillings*

Investigators concerned with fruit trees and other perennial plants will welcome the appearance of this book which deals with experimental techniques relating to these crops. Investigations with perennials have been less prominent than those with some annuals, but have increased in importance in recent years. The book is designed as a guide for persons with a basic knowledge of statistics who are making a start in long term experimentation. A wide range of topics, from experimental designs to plant measurements, are discussed in 97 sections. The problems and techniques are discussed from a biological point of view and many of the examples are drawn from the author's own experiences. A large bibliography is given, but it is felt that in many cases a short explanation could be given instead of referring the reader directly to another author. Some omissions will be noted by experienced readers. For instance, Section 63 contains a lengthy description of a method for grouping varieties in related trials, but no mention is made of the usual practice of comparing different varietal trials by using common varieties as controls. However, the author is to be congratulated on the manner in which the subject matter is presented and for presenting the first publication devoted exclusively to this subject.—B.G.D.B.

SOIL STUDIES

THE PRODUCTIVITY OF CACAO SOILS AND ITS IMPROVEMENT

By

F. HARDY

(*Imperial College of Tropical Agriculture*)

Introduction

Various aspects of cacao ecology have been studied in the Department of Soil Science and Chemistry of the Imperial College of Tropical Agriculture in Trinidad, and the results have been published in a series of Annual Reports on Cacao Research, Nos. I to XI 1930 to 1951 inclusive, and two short Interim Reports for 1944 and 1945. The expansion of the College Cacao Research Scheme since 1948 has necessitated a recontinuation of the publication of annual reports, and a new report covering the period 1945 to 1951, is now being prepared for publication. This article deals with some results and conclusions so far reached by the "Chemical and Ecological Section" as a result of about fourteen years of discontinuous investigations of cacao soils and cacao plant nutrition; it summarizes the ground covered between 1930, when the Cacao Scheme was launched, to the end of the War in 1945.

(1) *The Organic Status of Cacao Soils*

It was early found that the "good" or high-yielding cacao soils of Trinidad, Tobago and Grenada show a higher C/N ratio than the "bad" soils. Although the full practical significance of this difference was not appreciated at the time, it was suggested that cacao soils whose organic matter is only slightly decayed and consequently display high C/N ratios would favour the incidence and development of mycorrhiza which, it was thought, might aid in the nourishment of the cacao tree. This suggestion was followed by the actual discovery of mycorrhiza in the cacao soils of Trinidad by E. E. Pyke (Botanical Officer).*

(2) *Mulching*

If low productivity in cacao soils is characteristically associated with organic matter having low C/N ratio, then the deliberate addition of high-ratio vegetable residues should ameliorate the biological condition of poor cacao soils, and so eventually raise their productivity. This possibility suggested the need for mulching experiments to test the C/N ratio theory.

(3) *Cacao nutrition*

The work of E. C. Humphries (Plant Physiologist) has indicated that the failure of cacao pods to mature (between 20 and 90 per cent. of the pods set are lost by wilting) is mainly caused by shortage of water and nutrients and by

* Pyke, E. E. (1934) Mycorrhiza in Cacao. *Fourth Annual Report on Cacao Research*, pp. 41–48.

competition in the tree between developing pods and leaf flushes. Nutritional defects thus seem to be one of the main direct causes of low yields. Experience with manuring cacao with fertilizers has shown, however, that although yields may immediately be increased greatly, the increments are not proportional to the amounts of fertilizer applied, nor can yields be forced above a certain limit which is soon reached in most cases. Fertilizers (particularly phosphates) seem to act on cacao soils as stimulants rather than nutrient providers. The nutrition of the cacao tree thus appears to be complex and apparently depends, not only on the chemical status of the soil, but also on its biological condition which decides the processes of breakdown of plant residues, as well as the liberation of nutrients, including trace elements, and possibly also the means for their absorption by the roots in symbiosis with the mycorrhizal agent.

(4) *Cacao root-systems*

In loose sandy soils and in open-structured clay soils not liable to continuous waterlogging, several (up to 5) whorls of laterals may develop at different levels, and the distribution of rootlets within the humic layer may be widespread and relatively deep. In compact silty and clayey soils prone to waterlogging, and in sandy soils having permanently high water-tables or compact subsurface layers, only few lower laterals develop, and these are thin, short and tortuous. Root extension in these cases is confined to a very shallow surface layer of soil usually less than 6 inches thick, and the distribution of rootlets is entirely superficial, a distinct root-mat ("biche") being formed over the conspicuous but thin crumb-mull in which the woody laterals are embedded, which grades rapidly (at the 3-inch depth) into the fine-grained soil below. The close association between "feeding roots" and decaying organic matter is an important ecological feature of cacao root systems in undisturbed soils in Trinidad which can scarcely be overstressed.

(5) *Soil animals*

A striking characteristic of the cacao soils of Trinidad is the abundance of small soil animals within the humic layer. Actual counts (of Arthropods) made by E. J. H. Berwick* gave an average number of 150 million individuals per acre to 9 inches of soil, of which 60 per cent. occurred in the top 3 inches. (Earthworms, though present, are much less common in Trinidad than in temperate countries). The chief Arthropods found were Arachnids—72 per cent. (mainly Acarina (Mites)) and insects—28 per cent. (mainly Collembola (Springtails)—18 per cent., together with species of ants—7 per cent.—and of Coccids—3 per cent.). Differences in the numbers of the various kinds of soil animals at different times of the year in different cacao soil-types and in shaded and unshaded fields on the same soil-type, proved to be statistically significant, leading to the important conclusion that "the numbers and character of the soil fauna may be used as an index of the fertility of the soil". Thus, the ratio of the number of Collembola to that of Acarina increased with apparent increase of porosity and soil aeration, but decreased with "heaviness" of soil and compactness of the root and leaf-mat. This finding agrees with the

* Berwick, E. J. (1935) A Preliminary Survey of the Soil Fauna of some Trinidad Agricultural Lands. Dissertation, *I.C.T.A.* pp. 63.

general conclusion reached regarding cacao nutrition, namely, that the chief distinguishing feature between "good" and "bad", and between "new" and "old" deteriorated cacao soils lies, not only in their different physical and chemical condition, but mainly in their biological condition.

Further work on the micro-fauna of forest and cacao soils carried out by A. H. Strickland* has substantiated these findings and has shown that the distribution in depth of soil animals falls off rapidly below the first 2 or 3 inches. He found that the ecological environment influences the magnitude of the Arthropod soil population more than the pedological soil-type.

(6) *Drainage; water supply; aeration*

Intimately bound up with the biological and biochemical changes which affect leaf litter and soil organic matter in cacao fields, as well as the penetration and distribution of roots of cacao trees, are the seasonal fluctuations in water and oxygen supply of the soil. Recently these have received detailed study at the College, and some unexpected results have emerged.† It appears, for example, that many of our sandy alluvial cacao soils, such as the soil at River Estate Experiment Station, are inadequately supplied with oxygen during most of the wet season, because they are almost completely saturated with water, especially below the 6 inches depth, for relatively long periods of time. On the other hand, most of the clayey soils never dry out at all below the 18 inches depth, though their surface layers in some cases may possess an open crumb structure so that aeration (at least to the 3 or 4 inches depth) may be fairly good, even in wet weather. Many of the clay soil-types crack deeply during drought, and this property is believed by some planters to be advantageous, presumably because it aids in soil aeration and drainage during the early part of the wet season before the cracks become sealed by swelling, and in self-mulching.

Problems of drainage involve considerations of soil porosity as decided by natural structure, as well as of topographical site. Instances could be cited where attention to the thorough drainage of cacao soils has caused marked improvement in aeration, so that biological conditions have been ameliorated and root-development has consequently been encouraged.

(7) *Conclusions*

The evidence presented above has led to the conclusion that *the chief cause of the decline and falling productivity of the cacao soils of Trinidad is the slow deterioration of their organic matter component, comprising the uppermost*

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* Strickland, A. H. (1945.) A survey of the Arthropod Soil and Litter Fauna of some Forest Reserves and Cacao Estates in Trinidad, B.W.I. *J. Anim. Ecol.* **14**: 1, 1–11.

† Vine, H., Thompson, H. A., and Hardy, F., (1941). Studies on Aeration of Cacao Soils in Trinidad. Pts. I and II, *Trop. Agriculture, Trin.* **19**: 175–180 and 215–223.

———————————————(1943). Studies on Aeration of Cacao Soils in Trin idad. Pts. III and IV, *Ibid.* **20**: 13–24 and 51–56.

Also Ha rdy, F., (1943). Studies on Aeration and Water Supply in some Cacao Soils of Trinidad. *Trop. Agriculture, Trin.* **20**: 89–104.

humic layer of the soil profile. Either this has gradually been lost through sheet erosion, or it has slowly decomposed into more resistant residues having lower C/N ratio, the supply of fresh, natural, high-ratio material in the form of fallen leaves, flowers, and twigs not having been adequate for the maintenance of the initial organic status. Such a change would seriously affect the whole range of biological reactions that proceed in the surface humic soil in which it is known that the feeding roots of cacao mostly occur, in particular, the activities of mycorrhiza and of other important soil fungi, as well as of soil animals. Much mineral nutrient matter (especially phosphate, which is intimately associated with organic residues) would consequently be leached away and lost instead of being absorbed into the trees, and possibly also, nitrogen nutrition would be adversely affected through the improper breakdown of the litter.

SOIL RESTORATION

By Edward H. Faulkner. *Michael Joseph, Ltd., London, W.C.*1, 1953. *Pp.* 207. *Price* 10*s.* 6*d.*

This book was written by the author of "Ploughman's Folly" and "Ploughing in Prejudices" which have evoked so much discussion by agriculturists the world over. In order to demonstrate the validity of his arguments and previous experience, Faulkner bought a small farm which he cultivated for seven years by the methods he has long advocated. The results of his further experience are described in this his latest book. The question is not just merely "to plough or not to plough", but rather whether his methods can make possible the cheap and sure restoration of impoverished "tired" soil. He severely chastises the scientists who have been so fully occupied by economic problems that "they have had little time to consider farming practices from the standpoint of the consumer's health". In the foreword, Mr. Graham Brade-Birks admits that Faulkner is "a bit hard on the scientists", and that some of his ideas may be based upon misapprehensions, though not necessarily invalidating his main arguments. Faulkner's practical experiments on his own land have yielded some striking results, though further research may show that they may not all mean what he thinks they mean, particularly for other localities and for other kinds of soils. At no time has he used "artificials", lime, compost or other soil amendments, nor even stable manure, since he does not go in for animals. Whatever changes have come over his soil must therefore be credited solely to the fact that "the remnants of each crop have been faithfully mixed into the soil before the next crop was planted". Herein lies his secret. Naturally, Faulkner agrees with those who maintain that the "cure" for most soil evils and for deficiency and many other diseases in animals and man lies in increasing the organic matter content of the soil, though indisputable proof of this is not yet forthcoming from well-planned, long-term, agricultural experiments. In the meantime, we all wait for the completion of such experiments and would prefer to withhold judgement until it is forthcoming.—F.H.

ECONOMICS AND TROPICAL DEVELOPMENT

SOCIAL AND ECONOMIC STUDIES

Institute of Social and Economic Research, U. C. W. I., Jamaica, B.W.I. Vol. 1, *No.* 1, *February,* 1953. *Pp.* 119. *Price* 5*s.* 3*d* ($0.75 *U.S.*)

This attractively produced periodical is the first of its kind published by Institute of Social and Economic Research at the University College of the West Indies, Jamaica. The series will presumably be published intermittently as material comes to hand.

The present number is not intended to be of much interest to the agriculturist. It is true that about half of the longest article, occupying half the issue deals chiefly with the agricultural setting of Jamaican industrialisation, but this review does not claim to be an exhaustive history of Jamaican agriculture in recent years. The other articles deal with the productivity of Jamaican industry, and family structure in a rather atypical village in British Guiana.

A review of the work and plans of this young Institute would have been of interest and, it is hoped, will be included in the next issue.—A.L.J.

AN ECONOMIC SURVEY OF THE COLONIAL TERRITORIES, 1951, VOL. IV—THE WEST INDIAN AND AMERICAN TERRITORIES

H.M.S.O. 1953. *Pp.* 274. *Price* £2

The fourth volume in this admirable and authoritative series covers as wide a geographic area as any previously. From sub-tropical Bermuda through the tropical Caribbean to the sub-antarctic Falkland Islands. Not only is the range wide, but the individual territories, varying often from neighbour to neighbour, are small. It is inevitable in any review of this area for much space to be occupied with what is by other standards microscopic detail. Such variation form one small island to another, however, makes fascinating reading and this volume with its companions will provide a standard reference to the Colonial Territories until the series is revised.—A.L.J.

ECONOMICS OF AGRICULTURE IN A SAVANNAH VILLAGE

By Miss H. R. HASWELL. *Colonial Research Studies No.* 8., *H.M.S.O.*, 1953. *Pp.* 142. *Price* 15 *shillings.*

Miss Haswell has obviously acquired a very detailed knowledge of the social and economic status of a village community in the Gambia. She is to be congratulated on the valuable contribution she has made to knowledge of social structure and agricultural practices under conditions which are representative of very extensive areas of both West and East Africa.

The report is very fully illustrated with sketch maps, graphs and plans. There are also numerous tables of tabulated information.

A refreshing feature of the report is the entirely objective manner in which the facts have been presented.

This publication will be of particular value to Administrative and Agricultural Officers who will find it a most valuable source of information relative to rural development problems.—W.J.B.

AFRICA

A Study in Tropical Development

By L. DUDLEY STAMP. *John Wiley & Sons, Inc., New York. Chapman & Hall, Ltd., London.* 1953 *Pp.* viii + 568. *Illustrated. Price* $8.50 (U.S.)

This book grew out of a series of lectures on " Underdeveloped Lands " given at the University of Indiana by Dr. Dudley Stamp, Professor of Social Geography at the University of London, who is well-known for his books on land use surveys. Its aim is " to look at the Continent of Africa, to consider its geographical background as an environment for human activity, and to study the responses which have been evoked from its African inhabitants and those who have penetrated its fastnesses and molded its fortunes ". It is a sort of " stock-taking " with a view to future better land utilisation, involving the evaluation of geographic, historic, social and economic factors that have so far determined its development.

The book is divided into three parts ; the first part deals with the African Continent as a whole, its physical features, its climates, soils, forests, grasslands, deserts, peoples, pests and diseases, and ways of transportation, and is mainly descriptive. The second part separately considers the different countries and regions of Africa ; Egypt, the Mediterranean Region, the Sahara, West Africa, Sudan, Ethiopia and the Red Sea Region, Equatoria, East Africa, Central Africa and the African Seas and Islands. This too is mainly descriptive. The third part discusses the past, present and future problems of Africa in 12 pages. It examines the significance of the rapid development of transportation which has " changed the whole African scene " in recent years, partly through increasing the number of village shops and partly through making it easy for government agents to reach all parts of their districts. Along with this increased mobility has come a marked rise in the standard of living, the breaking down of the old isolation and a decline in rural arts and crafts. All this is resulting in an urgent need for better systems of agriculture and for vastly increased food production to meet the ever-increasing requirements of the multiplying population. These problems are not discussed, since they do not form the purpose of this book, which can be strongly recommended to those whose responsibilities lie in these directions, such as agricultural officers and administration cadets.—F.H.

COMMUNICATIONS ON ORIGINAL INVESTIGATIONS

MAIZE OF THE WEST INDIES[1]

By

WILLIAM L. BROWN,[2] B.A., M.S., Ph.D.

Introduction

During the past two and one half decades remarkable advances have been made in our understanding of centres of diversity, distribution and relationships of the major races of *Zea Mays* of Latin America. The investigations of Anderson (1946), Wellhausen et al (1951), Mangelsdorf and Cameron (1942) and Cutler (1946) to cite only a few, have laid the groundwork for a basic understanding of the maize of Mexico, a large part of Central America and to a somewhat lesser degree that of South America. The literature provides scattered references to Caribbean maize, (Kuleshov 1930), yet to date no detailed information is available on the maize of any one of the West Indian islands.

Compared with the multitudinous races of maize of South and Central America, the amount of variability among West Indian varieties is relatively slight and has therefore escaped the attention of most students of this fascinating grass. Likewise because of its secondary economic importance in the area it has, with the exception of some successful breeding work by del Valle (1952) in Cuba, received but little attention from plant breeders and agronomists of the area.

Despite these facts, maize of the West Indies is important for several reasons. It is widely distributed in both hemispheres, having been introduced into Europe by the early explorers and having spread from there to the Pacific and elsewhere. Its relation to the known races of maize of the Western Hemisphere is undetermined and any reasonably authentic information on this point should be of value not only to botanists of cultivated plants but to ethnologists as well since maize has long been a principal food source for Latin American peoples. Finally, because of its exceptional vigour and productivity it may well provide a source of valuable breeding material not only for the Caribbean but for maize growing areas of North and South America.

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[1] Much of the work reported here was done during the tenure of a Fulbright Advanced Research Award, 1952–53.

[2] Geneticist, Department of Plant Breeding, Pioneer Hybrid Corn Co., Johnston, Iowa, U.S.A.

It is hoped the facts gleaned from this study may add a bit to our rapidly growing basic understanding of this important crop plant, an understanding which becomes more and more necessary if one expects to further improve maize by the use of refined breeding techniques. If West Indian maize is to be improved or if West Indian varieties are to be intelligently employed in maize improvement programmes elsewhere, a general classification of the major races within the area and an understanding of the range of variation between and within races become a necessary prerequisite.

Maize of the West Indies has undergone a history so complicated that to unravel all of its details from a study of modern varieties is all but impossible. At least three cultures of peoples, two of which were known to be agricultural, inhabited the area in pre-Columbian times. The problem has been further complicated in post-Columbian times by the invasion of numerous groups, Spanish, African Negroes, Orientals, Europeans and Americans, each of whom have had some influence upon the agricultural history of the area. The free migration of peoples between islands and between the islands and the mainland has certainly aided in the intermingling of varieties of maize and has therefore, at least partially masked the racial differences which might have been transparent in pre-Columbian times.

The problem of classification, although difficult as a result of the many complicating factors involved, is not completely chaotic. While the cultural and geographic factors affecting maize of the West Indies have been of such nature as to encourage intervarietal hybridization and result in a masking of racial tendencies, a strong genetic linkage system characteristic of maize, (Anderson and Brown 1952), has apparently operated at the same time as a powerful force in preserving in a still recognizable state these same racial characteristics. Thus, as will be shown later, it would seem that the essential features of the pre-Columbian maize pattern have been preserved.

Ethnic Groups

According to Rouse (1948a) the West Indies were inhabited by three cultural groups at the time of historic contact, the Ciboney, Arawak and Carib, who apparently appeared in the islands in that order. Rouse (1948a) states, "that the Ciboney were the original inhabitants of the West Indies is suggested by their peripheral position during historic times . . . . . It is also indicated by their archaeology, for traces of a pre-agricultural hunting and fishing population have been found throughout Cuba and in many parts of Haiti besides the peninsula of Guaicayarima, apparently at an earlier date than the *Arawak* population wherever the two happen to overlap . . . . . There is little doubt that the *Ciboney* were more widely distributed during prehistoric than historic times and that they were pushed back into their historic position as a result of the advent of the more advanced *Arawak* and *Carib*."

The Ciboney are assumed to have been non-agricultural, subsisting by means of hunting and fishing. It is unlikely that they used maize since no

maize remains have been found in their archaeological sites. Although archaeological opinion differs as to derivation of the Ciboney it is rather generally concluded that they came into the West Indies from Florida.

The Arawak followed and to some extent replaced the Ciboney in the West Indies. They are presumed to have entered the West Indies from South America by way of Trinidad and The Lesser Antilles (Rouse, 1948b). They were encountered by Columbus in the Bahamas, Cuba and Hispaniola during his first voyage in 1492–93. According to Rouse (1948b) the Arawak differed from the Ciboney both in language and culture. They had a well-developed agriculture and in Western Haiti particularly they are reported to have practised irrigation (Rouse, personal communication).

Following the establishment of permanent European settlements in the West Indies the Arawak were soon conquered, exploited, and finally subjected to the horrid system of repartimientos according to which each chief was forced to provide a certain number of Indians to serve as forced labour in the Spanish gold mines. This, in addition to frequent slave raids, soon reduced the Arawak population of most of the islands except Cuba to a mere remnant. In Cuba the Indians survived the exploitation of the Spanish and when the system of repartimientos was abolished in 1550 approximately two thousand Indians remained on the island, as compared with 700 Spanish.

Maize was an important item in Arawak agriculture. Its culture as practised by these Indians was similar to that of most primitive South American peoples, a typical slash-and-burn system of cultivation. It is to be assumed that the Arawak brought maize with them from South America since they had reached the agricultural level of culture upon arrival in the West Indies. Little is known however of the types of maize they used. Rouse (1948b) states in discussing the Taino (a sub-group of the Arawak) of Hispaniola, "From the absence of metates in pre-historic times, it has been assumed that the *Taino* had only a soft variety of corn." In the writer's opinion the absence of metates does not necessarily mean that hard corn was not used since many of the extreme flint corns could have been parched or partially popped and thereby made edible without previous grinding. In fact, some of the modern strains of West Indian maize of South American origin are admirably adapted to this mode of utilization and in parts of Haiti are still used to a considerable extent as parched and semi-popped grain.

The third group of Indians to inhabit the West Indies were the Caribs, who, like the Arawak, were of South American origin. They are supposed to have reached the West Indies not more than a century prior to the Discovery and as a result of their aggressive warlike nature they had by that time conquered all of the Lesser Antilles as well as a part of Trinidad. Since the Carib villages were moved frequently and since these Indians apparently spent a great deal of their time in raiding the Arawak, it is unlikely that their agriculture was as highly developed as that of the Arawak. They did however cultivate maize as well as most other plants used by the Arawak.

The Area

Although not all the West Indian islands are included in the present survey, it is felt that the collections from the area covered are sufficient to represent a fair cross-section of Caribbean maize. The islands from which maize was studied are shown in Figure 1 and include Cuba, Jamaica, Haiti, Dominican Republic, Puerto Rico, St. Croix, St. Kitts, Antigua, Dominica, Martinique and Trinidad. With the exception of Puerto Rico, St. Kitts and Antigua, experimental cultures from field collections were grown and studied in detail. In Puerto Rico and Antigua, maize was studied by the author in the field but no collections were made. Material from Puerto Rico is treated only lightly in this report. The problem there is a most complicated one in that original racial tendencies are more or less obscured by the introduction in recent years of numerous kinds of maize from the outside. The classification of all maize types currently in use in Puerto Rico is a research project in itself. The island of St. Kitts was not visited by the author but material from there has been provided through the kindness of the Agricultural Superintendent, St. Kitts Department of Agriculture.

While certain of the races of maize characteristic of the West Indian islands occur also in the Caribbean coastal areas of Central and South America no attempt has been made to include them in this study. Some of these races have been described in previous works by Cutler (1946), Anderson and Cutler (1942) and Wellhausen et al (1951), and it is expected that they will receive further attention during the course of the maize collection and preservation project currently being pursued by the National Research Council.

Neither time nor funds were adequate to include the Bahamas in the present work. It is unlikely that these islands would have contributed any maize types that are not found in certain of the other West Indian islands included in the survey. The few scattered collections of Bahamian maize that have been examined are duplicated in type by material from Cuba, Haiti and Jamaica.

Methods of Collection and Study

Most of the collections on which this study is based were made early in 1952 during the course of a survey of Caribbean maize conducted by the author at the request of the Committee on Preservation of Indigenous Strains of Maize of the National Research Council. Random ear samples were collected in the field and in corn granaries and these together with pertinent data were forwarded to Chapingo, Mexico. The samples were there incorporated into the N.R.C. maize collection currently being maintained at the Rockefeller Foundation Agricultural Experiment Station, Escuela Nacional de Agricultura, Chapingo, Mexico. Any requests for seed of these corns should be directed to the above institution rather than to the author.

The matter of obtaining maize collections which are representative of the population from which they come cannot be over-emphasized. All too frequently the material available for study has been selected because of its

FIG. 1. Map of a portion of the West Indies showing those islands from which maize was studied during the course of the present survey.

attractiveness or because it in some other way appeals to the tastes of the collector. A case in point has been described by Cutler (1946) in which from a harvest of some 8,000 ears of Bolivian maize, only four ears differed significantly from the predominating type. Yet a botanical collection which supposedly represented this lot of maize consisted of three atypical ears and only four of the major type. In order to avoid this type of error in the West Indian material, both field and stored ear collections were made at random in so far as was possible. The material supplied by co-operating individuals may or may not have been obtained in the same way.

In addition to observations made in the field, progenies of the original collections, consisting of approximately fifty plants each, were grown and studied in the experimental gardens of the Imperial College of Tropical Agriculture, Trinidad. This planting was done in the latter part of October 1952, and due to the favourable growing conditions which prevailed during the succeeding four months, a normal and entirely satisfactory crop resulted. Each of the West Indian collections seemed well adapted to Trinidad conditions and produced normal specimens for study and record.

At anthesis the following plant and tassel measurements were made on ten plants of each collection: length of husk leaf blades, number of secondary tassel branches, number of tertiary tassel branches, length of central spike of tassel, diameter of culm at the base of the tassel, length of tassel exsertion beyond the uppermost leaf sheath, angle of branching of the secondary tassel branches, and the degree of condensation of spikelet pairs of the lowermost secondary tassel branch. This involved some ten thousand measurements or scores distributed among one hundred and thirty-five cultures. To conserve space in publication only summaries of these data (Table 9), as they apply to the major races are included in this report. The complete data, however, are included with the herbarium specimens[3] where they are available to the interested investigator.

Also at anthesis, typical plants and tassels of each collection were photographed and a portion of a representative tassel of each collection was preserved for subsequent use in the herbarium record. Internode measurements were also made at this time. From these measurements the average internode pattern of each of the major races was determined and plotted graphically (Fig. 2).

At maturity all ears of the progeny of each collection, excluding obvious nubbins, were harvested, labelled and the entire crop was spread out on greenhouse benches where it was easily accessible for study. The ears of each of the 135 cultures were then photographed for the herbarium record before being separated and assigned to distinct classes or races.

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3 Herbarium specimens including plant and ear photographs and pertinent numerical data will be deposited at the completion of these studies in the Collection of Economic Plants, Missouri Botanical Garden, St. Louis, Missouri.

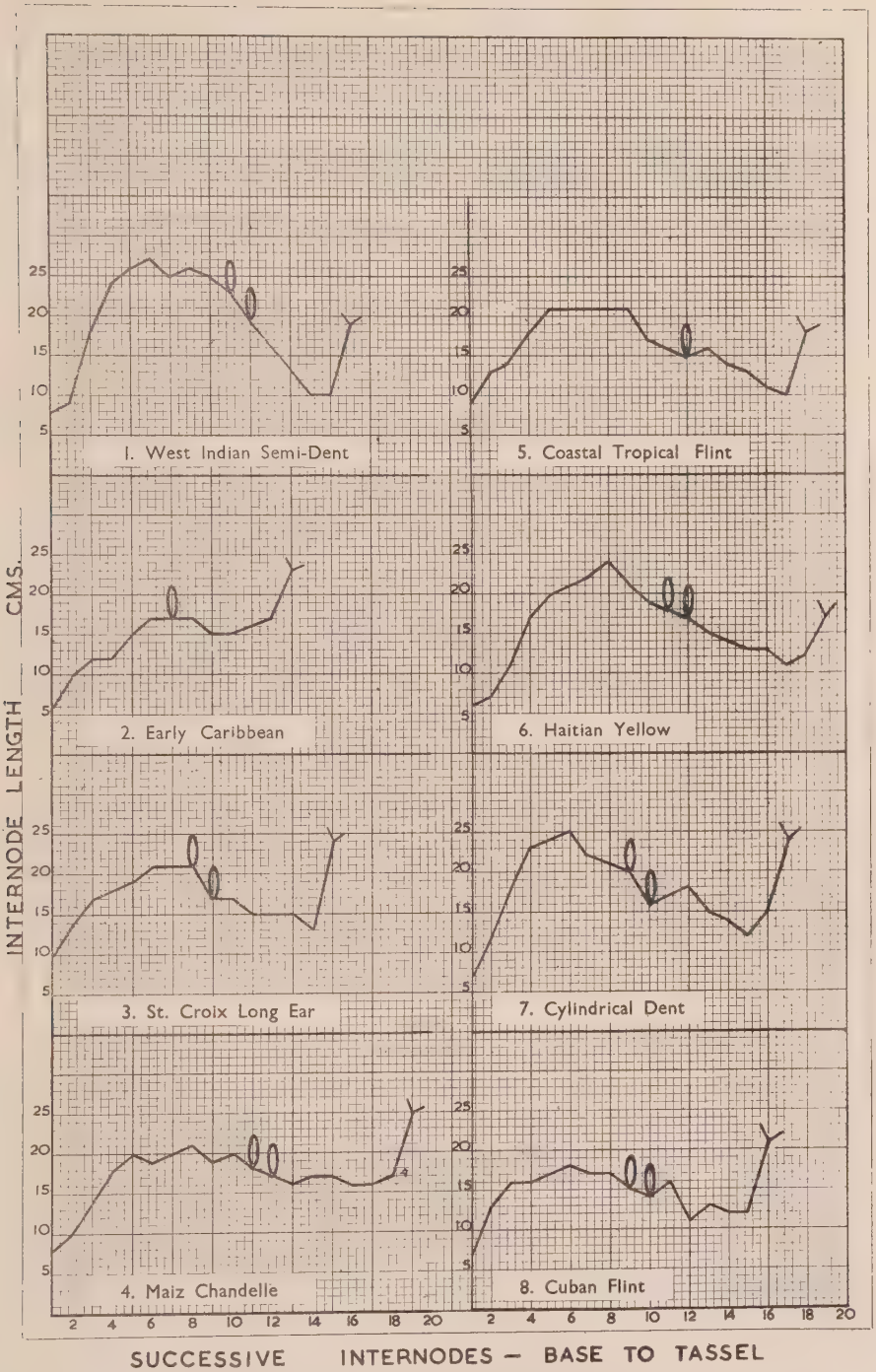

FIG. 2. Average internode diagrams of eight races of West Indian maize. Each diagram represents the mean of measurements of ten plants. Position of ears are designated by ellipses and the terminal branched line indicates position of tassel.

Particular attention has been given the selection of morphological characters used in determining racial differences. Certain characteristics of maize, although strikingly conspicuous, are of a superficial nature since their expression is governed by the action of one or at most a few gene pairs. Examples of such differences are those of seed colour, plant colour and to some extent texture of the endosperm. Of a more critical nature are those differences in form and proportion, particularly of the inflorescence. Thus differences in ear shape, degree of denting, internode pattern and degree and type of branching of the tassel are much more representative of the fundamental differences which taxonomists have long used in the deployment of genera and species. The usual multifactorial nature of inheritance of such characteristics is further evidence for their representing real differences in germ plasms.

After careful study of the collected ears referred to above it soon became apparent that despite the heterogeneous nature of the collection as a whole, several distinct morphological types tended to stand out. Eight such types, or groups, were finally recognized, after which the entire collection of ears was sorted, each ear being assigned to the group into which it fitted best morphologically. Many of the ears, of course, failed to fall into any of the eight categories. A number of these were temporarily assigned to intermediate groups while others which seemed to fit nowhere were relegated to a group labelled "unknowns". Further study reduced the number of ears in the intermediate and unknown groups until finally the eight groups together contained an appreciable part of the entire collection. Each of these groups will later be described and discussed separately under "races".

Twenty-five ear samples of each of the provisional races were then taken at random and scored for the following twelve characteristics: basal diameter, mid-ear diameter, shank diameter, kernel width, kernel thickness, kernel length, ear length, row number, denting[4], pericarp colour, pointing and endosperm colour. These accumulated measurements and scores are presented in Tables 1 to 8.

Races of West Indian Maize

Due partly to the absence of geographical and ethnic barriers and also as a result of selection pressure, the common maize of the West Indies is a recombination product involving two or more distinct varieties. This being true, the impression the student of maize gets upon seeing such material for the first time is that it is a hopeless mess. Most certainly the picture is complicated but not completely undecipherable. In fact, there now seems little doubt that the basic remnants of at least seven distinct morphological types have survived the masking influence of hybridization and are still present in the area

[4]Denting has been scored in five grades as follows :

0. No soft starch at apex of kernel
1. Soft starch but no denting
2. Soft starch and a small dent
3. Soft starch and a deep dent but no wrinkling of pericarp
4. Soft starch and wrinkling pericarp.

in recognizable forms and in sufficient numbers to represent what may be considered races[5]. An additional type, although apparently of hybrid origin, occurs with such regularity as to merit recognition as a race. The validity of these races is further enhanced by the fact that certain of them tend to have fairly well defined centres of distribution and others are obviously extensions of authentic types that have previously been described for the Central and South American mainland. Of the eight well-defined races present, three are apparently of rather recent origin while the remaining five probably represent old indigenous types.

General Characteristics

Most maize types of the West Indies have a sufficient number of morphological characteristics in common to distinguish them from maize of other areas and to permit a general description of type.

The plants are tall with long internodes, the internodes frequently being considerably longer than the accompanying leaf sheath. Leaves are long and relatively narrow in proportion to their length. Plants are usually glabrous and are without tillers. There is little anthocyanin coloration in either the culm or leaves. Tassels possessing many secondary branches are well exserted beyond the uppermost leaf sheath. Secondary tassel branches are attached to the main axis at a 90° angle or less. Drooping tassel branches so commonly found in Mexican and South American maize do not occur in the West Indies. Spikelet pairs are usually only slightly condensed, if at all.

Ears placed high on the plant are attached by relatively short shanks (peduncles) and are held in an upright position until well past maturity. Many plants produce two well developed ears although predominantly single eared varieties are not uncommon. Husks are of hard texture, usually extending well beyond the tip of the ears and are tightly wrapped around the ears thereby providing considerable protection against bird and insect damage.

Texture of the grain varies all the way from pure flints to extreme dents, however, the texture most frequently encountered is flint-like with a small capping of soft starch at the tip of the kernel. Endosperm colour is characteristically orange-yellow with the occasional occurrence of white capping. Colourless pericarp and aleurone are the rule although red pericarp is not uncommon in some of the early varieties.

Cuban Flint—(Table 1, Plate 1)

This race which represents the only true flint in the West Indies has short ears slightly compressed at the base and gently tapered toward the tip. Shanks are short and relatively narrow. The seeds are short and vary from flat topped to slightly pointed. Row numbers range from 12 to 16 with a mode

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The term "race" is employed here in its broadest sense and has essentially the same meaning as defined by Anderson and Cutler (1942) who state, "a race is a group of related individuals with enough characteristics in common to permit their recognition as a group."

TABLE I. EAR MEASUREMENTS OF CUBAN FLINT

Collectors Number	Basal Diameter mm.	Mid Ear Diameter mm.	Shank Diameter mm.	Kernel Width mm.	Kernel Thickness mm.	Kernel Length mm.	Ear Length cm.	Row Number	Denting	Pericarp Colour	Pointing*	Endosperm Colour	Source
Br—117 ...	54	48	22	9	46	9	21	14	0	—	1	Orange	Mayari, Cuba
Do. ...	45	43	18	8	37	10	20	14	0	—	1	do.	do.
Do. ...	45	41	18	9	37	10	16	12	0	—	2	do.	do.
Do. ...	47	45	19	8	42	8	18	16	0	—	1	do.	do.
Do. ...	48	45	19	8	37	9	17	16	0	—	1	do.	do.
Do. ...	48	44	19	9	41	8	23	14	0	—	1	do.	do.
Do. ...	41	41	13	9	42	10	14	14	0	—	1	do.	do.
Do. ...	49	45	16	8	40	9	16	16	0	—	1	do.	do.
Do. ...	48	45	17	9	36	11	16	14	0	—	1	do.	do.
Do. ...	48	46	19	9	35	10	18	14	1	—	1	do.	do.
Do. ...	54	47	23	10	40	9	18	12	0	—	1	do.	do.
Do. ...	48	44	17	8	39	9	17	16	1	—	1	do.	do.
Do. ...	54	49	17	9	42	10	19	16	0	—	2	do.	do.
Do. ...	47	45	18	9	35	8	16	14	0	—	1	do.	do.
Do. ...	45	42	12	9	38	8	19	12	0	—	1	do.	do.
Do. ...	46	42	16	10	32	8	19	12	0	—	1	do.	do.
Do. ...	48	46	11	9	35	10	16	14	0	—	1	do.	do.
Do. ...	45	44	16	9	41	10	14	14	0	—	1	do.	do.
Do. ...	48	48	14	9	36	11	16	16	0	—	1	do.	do.
Do. ...	50	46	20	10	40	9	22	14	1	—	1	do.	do.
Br—100 ...	50	46	13	8	44	10	16	16	1	—	1	Yellow	Madruga, Cuba
Do. ...	50	45	15	9	35	10	16	14	1	—	2	Orange	do.
Do. ...	46	42	16	8	37	10	15	14	0	—	1	Yellow	do.
Do. ...	47	44	15	10	36	10	17	14	1	—	1	Orange	do.
Do. ...	50	43	15	9	37	10	18	14	1	—	1	do.	do.
Mean ...	48.0	44.2	16.7	8.8	38.4	9.4	17.4	14.2	0.2	—	1.1		

* 1=No pointing; 2=Intermediate; 3=Extreme pointing:

of 14. Seeds are without pericarp or aleurone colour but the endosperm is an intense orange yellow. Cobs are white. Glumes of the pistillate spikelets are short and of intermediate texture.

The plants average 235 cm. in height and are without tillers or conspicuous husk leaf blades. In contrast to most West Indian maize the leaf sheaths of Cuban Flint are strongly pubescent. Husks are tight and extended well beyond the tips of the ears. Many plants produce two well-developed ears.

The tassels, which average 20 secondary branches, are exserted well beyond the uppermost leaf sheath. Tassel branches are conspicuously short in comparison to those of other races. Glumes of the tassel are short and thick and the pedicels of pedicellate spikelets are likewise short.

Under Trinidad conditions plants of this race reach the stage of anthesis approximately 60 days after planting.

The distribution of Cuban Flint in the West Indies is limited to Cuba where it is known by several local names, the most common being "Argentino" and "Francisco". It is more prevalent in the eastern than in the western part of the island. Although this maize is not as widely grown as some other types, the resistance of its hard flinty kernels to weevil attack is appreciated by growers who find it necessary to store their maize for any considerable length of time.

Cylindrical Dent—(Table 2, Plate 5)

The introduction of the genes for denting into West Indian maize probably has taken place through this race. At present it occurs only as a remnant and is undoubtedly less extreme in type than at the time of its original introduction. Its short thick ears which are nearly cylindrical have higher numbers of rows of kernels than any other race in the area. The grains are long, relatively narrow, well dented and frequently wrinkled. The horny starch of the endosperm is deep yellow in colour whereas the soft starch, in contrast, is light yellow or cream. Both pericarp and aleurone colour are absent. The flat topped kernels are closely crowded together and are conspicuously marked with husk striations at the base of the ear. Glumes of the pistillate spikelets are short and of rather soft texture.

The average number of days to anthesis is 63. Height of plants is approximately 300 cm. Ears which are frequently single are placed high on the plant and are enclosed in tight husks. Husk leaf blades are absent. Plants produce no tillers and are without conspicuous anthocyanin coloration.

The many branched, wide spreading tassels of Cylindrical Dent are one of its most conspicuous features. Compared to other races, condensation of the spikelet pairs of the secondary branches is also quite high. Although the average condensation index for the race is 1.5 it is not unusual to find tassels whose condensation indices are 2.0 or more.

TABLE II. EAR MEASUREMENTS OF CYLINDRICAL DENT

Collectors Number	Basal Diameter mm.	Mid Ear Diameter mm.	Shank Diameter mm.	Kernel Width mm.	Kernel Thickness mm.	Kernel Length mm.	Ear Length cm.	Row Number	Denting	Pericarp Colour	Pointing	Endosperm Colour	Source
Br—153 ...	54	55	13	7	33	12	18	20	3	—	1	Yellow	S. Grande, Trin.
Br—112 ...	51	51	15	7	32	12	16	18	3	—	1	do.	9 ki. W of Holguin, Cuba
Br—113 ...	54	53	19	9	37	12	22	14	4	—	1	do.	3 ki. NE of Holguin, Cuba
Br—111 ...	57	55	18	9	40	12	17	16	3	—	1	do.	St. Augustine, Trin.
Br—162 ...	53	52	17	9	43	12	22	16	4	—	1	do.	Nr. St. Augustine, Trin.
Do. ...	50	50	16	8	40	11	19	16	3	—	1	do.	do. do.
Br—157 ...	61	60	18	9	38	13	16	16	3	—	1	do.	S. Grande, Trin.
Br—162 ...	58	55	12	9	43	12	20	16	4	—	1	do.	Nr. St. Augustine, Trin.
Br—164 ...	60	54	18	9	32	12	17	16	3	—	1	do.	Nr. Sibanicu, Cuba
Do. ...	57	57	19	9	38	11	19	16	3	—	1	do.	do. do.
Br—110 ...	60	56	18	9	38	12	20	16	3	—	1	do.	20 ki. W of Holguin, Cuba
Br—113 ...	55	57	19	9	49	13	23	16	4	—	1	do.	3 ki. NE of Holguin, Cuba
Br—166 ...	55	53	17	8	43	11	17	18	3	—	1	do.	Nr. St. Augustine, Trin.
Br—161 ...	58	57	20	9	33	13	21	16	3	—	1	do.	2 mi. S of Arima, Trin.
Br—165 ...	58	56	18	9	38	11	20	16	4	—	1	do.	Nr. St. Augustine, Trin.
Do. ...	56	55	18	10	40	11	19	14	3	—	1	do.	do. do.
Br—155 ...	52	52	15	8	43	12	18	18	4	—	1	do.	S. Grande, Trin.
Br—153 ...	59	58	17	9	39	12	18	20	3	—	1	do.	do. do.
Br—157 ...	57	59	16	11	40	12	15	14	3	—	1	do.	do. do.
Br—155 ...	55	55	19	9	37	11	17	16	4	—	1	do.	do. do.
Br—157 ...	56	57	13	8	39	12	14	18	3	—	1	do.	do. do.
Br—107 ...	57	57	19	9	48	11	16	18	3	—	1	do.	Victoria de las Tunis, Cuba
Br—159 ...	49	48	17	9	29	13	16	14	4	—	1	do.	4 mi. S of S. Grande, Trin.
Br—164 ...	54	53	18	10	35	11	19	14	4	—	1	do.	Nr. St. Augustine, Trin.
Br—165 ...	51	50	18	9	37	11	17	16	3	—	1	do.	do. do.
Mean ...	55.4	54.6	17.0	8.4	38.5	11.8	18.2	16.3	3.3	—	1.0		

The soft texture of the endosperm which renders it quite susceptible to weevil damage has prohibited the wide-scale use of Cylindrical Dent in a pure form. It is never found growing as a variety yet it constantly occurs as a segregate in certain areas. Despite its limited use in modern times it has contributed in no small way to the hybrid vigour of some of the more widely accepted semi-dents. At the present time it has a higher concentration in Trinidad than in the other islands although it is not uncommon as a segregate in Cuba. It likewise occurs infrequently in Haiti. With the possible exception of Puerto Rico, where it is difficult to distinguish between Cylindrical Dent and more recent introductions, it has not been found in the other islands.

Haitian Yellow—(Table 3, Plate 6)

Haitian Yellow is one of the most distinct races in the West Indies and so far as is known its distribution is limited to Haiti where it is concentrated in the western half of the south-western peninsula.

The ears which are of medium length, averaging about 18 centimeters, have conspicuously enlarged bases and are strongly tapered toward the tip. Ears are attached by brittle hard shanks which characteristically have many condensed internodes near the ear attachment. Kernel row numbers vary from 8 to 14 with a mean of 11.1. The kernels are widest at midpoint, are strongly pointed, usually with a slight capping of soft starch and are sometimes minutely dented. Endosperm colour is characeristically yellow although an occasional white grain is encountered. Pistillate glumes are strongly indurated as in many Tripsacoid types.

Plants of Haitian Yellow are as distinct as the ears. They possess exceptional vigour, are of late maturity (74 days to anthesis) and the culms and leaf sheaths exhibit strong purple anthocyanin coloration. In contrast to other races they have well developed husk leaf blades. Plants are free of tillers. The ears are high and are enclosed in an unusually large number of very hard, stiff husks. In the field this race appears to have exceptionally large ears but the impression is false; the apparent ear size is due to many thick husks which when removed reveal ears of very ordinary size. Leaves tend to be wider and thicker than those of Cuban Flint or Cylindrical Dents but are very similar in size, proportion and texture to those of Maiz Chandelle which will be described later.

Tassels of this race tend to be upright in habit. Secondary branches are relatively short and the branch internodes are without condensation.

Haitian Yellow is apparently quite similar to "Guatemalan Tropical Flint" described by Anderson and Cutler (1942). It would seem, however, that their material had smaller ears, less swollen ear bases and more variability than that described here. Furthermore since Guatemalan Tropical Flints are reported by Anderson and Cutler to occur in Cuba and since Haitian Yellow herein described has been found only in Haiti, it is felt the two races are distinct although probably related.

TABLE III. EAR MEASUREMENTS OF HAITIAN YELLOW

Collectors Number	Basal Diameter mm.	Mid Ear Diameter mm.	Shank Diameter mm.	Kernel Width mm.	Kernel Thickness mm.	Kernel Length mm.	Ear Length	Row Number	Denting	Pericarp Colour	Pointing	Endosperm Colour	Source
Br—130 ...	54	48	21	10	35	10	18	12	2	—	3	Yellow, few white	Marfranc, Haiti
Do. ...	47	43	19	9	35	10	16	12	1	—	3	Yellow, white mixed	do. do.
Do. ...	45	37	16	9	34	8	15	12	2	—	2	Yellow	do. do.
Do. ...	43	40	20	10	38	9	19	10	1	—	2	do.	do. do.
Do. ...	46	42	15	9	37	9	17	12	1	Bronze	3	do.	do. do.
Br—133 ...	41	39	15	8	37	9	19	12	1	—	3	do.	Josapha, Haiti
Br—132 ...	42	39	17	8	39	9	19	12	2	—	2	do.	W of Jeremie, Haiti
Do. ...	49	41	21	11	41	9	19	10	2	—	2	do.	do. do.
Do. ...	48	41	21	11	41	9	20	10	1	—	2	do.	do. do.
Br—167 ...	51	45	19	9	32	11	18	14	1	—	3	Yellow, white	SW of Moron, Haiti
Br—168 ...	51	42	17	11	40	10	19	8	2	Bronze	2	Yellow	Moron, Haiti
Do. ...	45	39	18	9	29	9	19	12	1	—	2	do.	do. do.
Do. ...	46	39	19	9	42	10	18	12	2	—	3	do.	do. do.
Do. ...	48	40	17	10	31	10	19	12	1	—	2	do.	do. do.
Br—124 ...	46	39	20	9	40	10	19	12	1	—	2	do.	W of Moron, Haiti
Br—130 ...	45	41	19	10	36	10	20	10	1	—	3	do.	Marfranc, Haiti
Do. ...	50	42	20	10	39	10	18	12	1	—	2	do.	do. do.
Do. ...	42	38	18	9	42	10	20	12	1	—	2	do.	do. do.
Do. ...	46	40	19	9	37	8	17	12	1	—	3	do.	do. do.
Br—167 ...	51	42	17	9	39	9	17	12	1	—	3	do.	W of Moron, Haiti
Br—168 ...	49	41	18	9	39	9	20	12	1	Red	3	Yellow, white	Moron, Haiti
Br—122 ...	47	39	19	10	36	9	20	10	2	—	2	Yellow	Camp Perrin, Haiti
Do. ...	47	39	19	9	39	10	18	10	1	—	3	do.	do. do.
Do. ...	43	36	19	10	34	9	19	8	1	—	2	do.	do. do.
Br—123 ...	42	35	15	10	34	9	17	8	1	—	2	do.	Nr. Moron, Haiti
Mean ...	46.5	40.2	18.2	9.4	37.0	9.4	18.4	11.1	1.2	—	2.4.		

Coastal Tropical Flint—(Table 4, Plate 3)

This name has been used previously by Cutler (1946) to describe a similar type of maize widely distributed in coastal areas of eastern South America. It is one of the most common corns of the West Indies and is the type ordinarily referred to in the United States as Caribbean Flint. The race was apparently introduced into Europe soon after the Discovery and has spread from there to many of the Pacific islands. In the pre-hybrid corn era it was also used rather extensively in southern United States where it is commonly known as Creole Flint.

The ears are long with slightly enlarged bases and have 12–16 rows of slightly pointed grains. The race is not a true flint as practically all specimens have a small but distinct capping of soft starch at the apex of the kernel. The grains which are only slightly longer than wide, are without aleurone colour but sometimes have a slight reddish tinge to the pericarp. Endosperm colour is characteristically deep yellow but lacks the orange pigment found in Cuban Flint. Pistillate glumes are of relatively soft texture.

Plants are of medium maturity, reaching anthesis in approximately 68 days after planting. Leaves are long and proportionately narrow, medium green in colour with nearly glabrous sheaths. Plants are without tillers and have faint reddish anthocyanin coloration at the base of the culm.

Secondary branches of the tassels are many (mean = 25.2) heavy and more or less drooping. Occasional plants exhibit considerable condensation of tassel branch internodes although the average condensation index is low (1.2).

Although Coastal Tropical Flints are found throughout the West Indies, the highest concentration of typical representatives of the race seems in modern times to be on the island of Dominica. Whether or not this is in any way related to the long persistence of Carib Indians on Dominica is an interesting point for speculation.

Maiz Chandelle—(Table 5, Plate 4)

Probably the most interesting race of maize in the West Indies from the morphological viewpoint is Maiz Chandelle. The name is that applied to this type of maize by conservative farmers in the more isolated parts of Haiti and is retained here because it admirably describes the ear shape of the most typical specimens.

There are two types of Maiz Chandelle, a semi-flint and a dent. The semi-flint has been found only in Haiti and Cuba while the dent form occurs in Cuba, Dominican Republic and Trinidad. It is not common in any of these areas and is difficult to come by since it apparently is grown only in out of the way places by long established conservative families. For this reason it is thought to be one of the older types of maize in the West Indies.

TABLE IV. EAR MEASUREMENTS OF COASTAL TROPICAL FLINT

Collectors Number	Basal Diameter mm.	Mid Ear Diameter mm.	Shank Diameter mm.	Kernel Width mm.	Kernel Thickness mm.	Kernel Length mm.	Ear Length cm.	Row Number	Denting	Pericarp Colour	Pointing	Endosperm Colour	Source
Br—170 ...	46	44	20	9	42	10	24	14	1	—	1	Yellow	Dominica
Do. ...	48	44	17	10	46	9	24	12	1	—	1	do.	do.
Do. ...	55	49	20	9	47	9	22	14	1	—	1	do.	do.
Do. ...	53	52	16	9	42	10	22	18	1	—	1	do.	do.
Do. ...	44	45	15	8	47	9	19	18	1	—	1	do.	do.
Do. ...	46	47	16	9	42	9	24	14	1	—	1	do.	do.
Br—172 ...	44	47	20	9	48	9	18	14	1	Slight	1	do.	do.
Do. ...	45	45	16	8	38	9	20	16	1	—	1	do.	do.
Do. ...	43	43	17	9	39	9	18	12	1	—	1	do.	do.
Br—174 ...	49	46	20	9	50	10	20	16	1	—	1	do.	do.
Br—172 ...	45	45	17	9	38	9	19	14	1	—	1	do.	do.
Br—170 ...	48	46	16	8	38	9	19	16	1	—	1	do.	do.
Do. ...	42	43	16	8	45	8	20	14	0	—	1	do.	do.
Br—173 ...	49	49	16	8	43	9	20	18	1	—	1	do.	do.
Br—171 ...	43	42	15	8	43	8	18	16	1	—	1	do.	do.
Do. ...	42	42	17	9	41	9	19	12	1	—	1	do.	do.
Do. ...	49	48	19	7	44	10	21	16	1	Slight	1	do.	do.
Br—172 ...	49	45	21	9	49	10	25	14	1	—	1	do.	do.
Br—171 ...	44	43	16	9	46	9	27	12	1	—	1	do.	do.
Br—172 ...	46	46	19	10	51	10	24	14	1	—	1	do.	do.
Br—175 ...	52	49	21	9	45	10	21	16	1	—	1	do.	do.
Br—174 ...	46	45	20	9	42	9	19	14	1	—	1	do.	do.
Br—172 ...	53	51	21	9	50	9	23	16	1	—	1	do.	do.
Br—174 ...	48	46	21	8	45	9	19	16	1	—	1	do.	do.
Do. ...	42	40	21	9	43	9	20	12	1	—	1	do.	do.
Mean ...	46.8	45.6	18.1	8.7	44.1	9.2	21.0	14.7	0.8	—	1.0		

PLATE 1—Cuban Flint

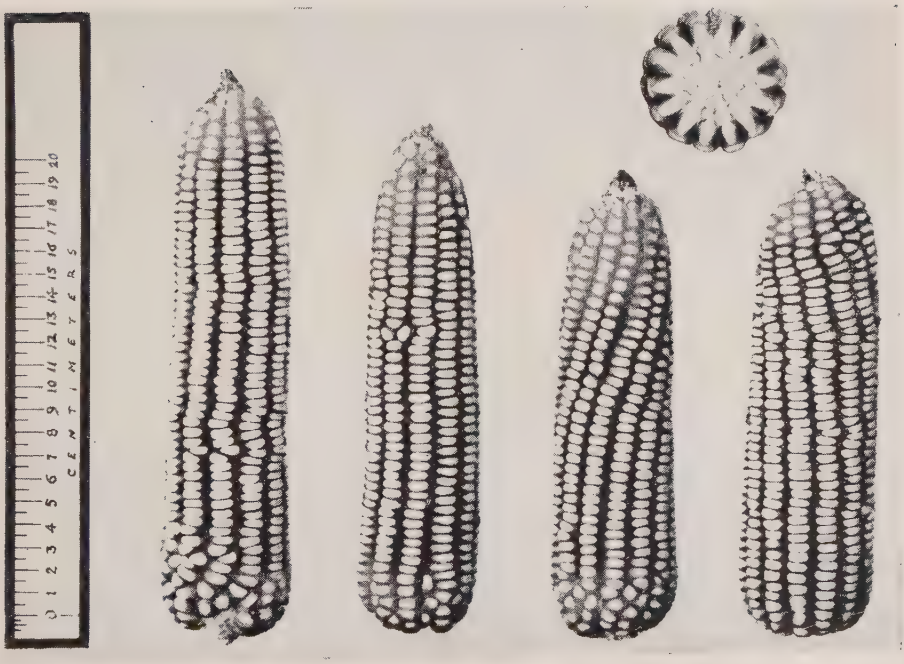

PLATE 2—West Indian Semi-Dent

PLATE 3—Coastal Tropical Flint

PLATE 4—Maiz Chandelle

PLATE 5—Cylindrical Dent

PLATE 6—Haitian Yellow

PLATE 7—Early Caribbean

PLATE 8—St. Croix Long Ear

The ears are long and narrow, strongly compressed at the base and gradually tapered toward the tip resulting in an ear shape very similar to that suggested by the name "chandelle". In most specimens a naked cob extends well beyond the ends of the rows of grain. Row numbers vary from 10 to 16 with a mean of 12.5. Kernels of the semi-flint form are long and narrow; are widest about two-thirds of the distance from the base to the tip and are slightly pointed. Most grains are capped with a small deposit of soft starch at the apex. Kernels of the dent form differ from the semi-flint in that they are not pointed and contain a higher proportion of soft starch and are consequently more dented. The kernels have yellow endosperm and occasionally a reddish tinge in the pericarp. Typical ears, particularly of the dent form, have a very flexible cob even when mature and dry. The mid cob is quite narrow and appears to have little lignification. The glumes are short and of feathery texture which permits ease of shelling of the grains.

Plants of Maiz Chandelle are not particularly distinctive except that the tassel is only slightly exserted and the culms are very tall. Average height when grown in Trinidad was approximately 325 cm. It is one of the later varieties of the West Indies, reaching anthesis 72 days after planting. The tassels have approximately 20 secondary branches of medium length and are without condensation.

As was mentioned previously, Maiz Chandelle occurs in Haiti, Cuba, Dominican Republic and Trinidad. In Cuba it is found only in the eastern end of the island and is most common in the mountain valleys and adjacent lowlands. It is there known by several names, the most common being "Maiz Canilla" and "Maiz Cuña". In Haiti it is found in the mountain areas of the western part of the south-western peninsula where a few older farmers who take pride in their crops still grow and maintain it as a relatively pure variety. The race occurs only rarely in Trinidad having been replaced in a large measure by the more productive flint-dent combinations. The only collection of Maiz Chandelle obtained there was from the foothills of the eastern part of the Northern Range. Here again it is grown only by the rare farmer who takes pride in maintaining the varieties inherited from his ancestors. In Trinidad, the variety, when known at all, goes by the descriptive name of "Deerhorn".

St. Croix Long Ear—(Table 6, Plate 8)

This type of maize which is very limited in distribution in the West Indies is so distinct morphologically that it is never confused with other races. The cylindrical ears, containing 10 to 14 rows of kernels, are very long. The large grains which are almost as wide as they are long are frequently well dented. The kernels of most specimens are quite flat at the top but an occasional ear may contain seeds that are slightly pointed. Kernels are characterized by light yellow endosperm, colourless aleurone and colourless or reddish pericarp.

Compared with other races the plants of St. Croix Long Ear are short. The leaves are proportionately wide for their length and the ears are placed

TABLE V. EAR MEASUREMENTS OF MAIZ CHANDELLE

Collectors Number	Basal Diameter mm.	Mid Ear Diameter mm.	Shank Diameter mm.	Kernel Width mm.	Kernel Thickness mm.	Kernel Length mm.	Ear Length cm.	Row Number	Denting	Pericarp Colour	Pointing	Endosperm Colour	Source
Br—122 ...	29	31	8	5	46	11	21	16	2	—	1	Yellow	Nr. Moron, Haiti
Do. ...	27	30	11	6	51	10	22	14	2	—	1	do.	do. do.
Do. ...	30	33	9	7	45	10	24	12	2	—	2	do.	do. do.
Do. ...	32	32	12	8	46	10	17	10	2	—	3	do.	do. do.
Do. ...	34	35	10	8	40	10	20	10	1	Red	2	do.	do. do.
Do. ...	31	32	9	7	40	10	21	12	2	—	1	do.	do. do.
Do. ...	32	36	11	6	34	11	17	16	2	—	1	do.	do. do.
Do. ...	26	26	9	7	38	10	18	10	1	—	2	do.	do. do.
Do. ...	34	31	9	7	39	10	19	12	2	—	2	do.	do. do.
Do. ...	30	31	9	6	40	10	18	14	1	—	1	do.	do. do.
Do. ...	34	35	9	8	34	10	18	12	1	—	1	do.	do. do.
Do. ...	27	29	9	6	38	9	15	12	2	—	1	do.	do. do.
Do. ...	38	36	14	8	39	11	18	12	1	—	2	do.	do. do.
Br—114 ...	33	34	11	8	37	11	19	12	2	Slight	1	do.	Tacamala, Cuba
Br—116 ...	30	34	9	7	36	12	20	12	1	—	1	do.	Mayari, Cuba
Br—106 ...	33	34	11	8	49	11	23	12	1	—	2	do.	Victoria de las Tunis, Cuba
Br—131 ...	33	34	10	8	43	11	21	12	1	—	1	do.	Cartaches, Haiti
Br—126 ...	33	35	11	8	38	10	22	12	2	—	1	do.	Petit-Ange, Haiti
Br—106 ...	32	36	9	8	37	12	21	12	1	—	1	do.	Nr. Holguin, Cuba
Br—116 ...	33	36	11	7	38	12	18	14	3	—	1	do.	Barajagua, Cuba
Do. ...	31	33	7	7	39	11	21	14	2	—	1	do.	do. do.
Br—126 ...	31	32	12	6	39	11	20	14	1	—	1	do.	Petit-Ange, Haiti
— ...	32	34	7	7	36	12	19	12	2	—	1	do.	La Vega, D. Rep.
— ...	31	37	7	7	47	13	19	14	2	—	1	do.	Santiago, D. Rep.
Br—122 ...	40	35	11	7	37	11	20	12	2	—	1	do.	Nr. Moron, Haiti
Mean ...	31.8	33.2	9.8	7.0	40.2	10.7	19.6	12.5	1.6	—	1.3		

low on the plant. Husks frequently are shorter than the ears and are not as tight as in most other West Indian maize. In this respect as well as in other vegetative characteristics this race compares favourably with many varieties of North American maize. Husk-leaf blades are present although they are not strongly developed in most plants.

Tassels have relatively few secondary branches. These are of medium length and are slightly condensed.

This race is comparatively early, reaching anthesis 56 days after planting.

St. Croix Long Ear, in the West Indies, is apparently limited to the island of St. Croix. There it is the most common type of maize and is highly esteemed because of its high productivity. For reasons which will be discussed later it is believed to have reached the West Indies rather recently.

Early Caribbean—(Table 7, Plate 7)

This is another race which stands out morphologically and is never confused with other types. It is a short season corn which flowers approximately six weeks after planting and matures a month to six weeks earlier than the latest West Indian varieties.

The ears which are of medium length (18.0 cm.) are slightly tapered and consist of 8–14 rows of semi-flinty grain. The grains are about as wide as long and are frequently crescent-shaped. There is little denting, despite the presence of a small deposit of soft starch at the tips of the kernels. Endosperm is yellow covered usually by a red pericarp.

The plants are short without tillers or prop roots and have only slightly developed husk-leaf blades. The internodes retain their length above the ear resulting in an internode pattern quite distinct from that of most West Indian varieties (Fig. 2). Ears are attached by upright shanks and are enclosed in short loose husks.

Tassels develop comparatively few secondary branches and the spikelet internodes are without condensation. Spikelets of the central spike are frequently decussately arranged and the pedicels of the pedicellate spikelets are unusually long.

This race was found only in two islands of the West Indies, Martinique and St. Kitts. It may occur in some of the other small islands which are not included in this survey but it certainly has a limited distribution in the area. Apparently it is the only type of maize grown in Martinique where it is used largely as a catch crop and planted in combination with peanuts, cassava, beans, bananas, &c. The smaller seeds carrying red pericarp are highly prized there as feed for fighting cocks.

TABLE VI. EAR MEASUREMENTS OF ST. CROIX LONG EAR

Collectors Number	Basal Diameter mm.	Mid Ear Diameter mm.	Shank Diameter mm.	Kernel Width mm.	Kernel Thickness mm.	Kernel Length mm.	Ear Length cm.	Row Number	Denting	Pericarp Colour	Pointing	Endosperm Colour	Source
Br—134 ...	57	54	23	12	47	13	26	12	3	Red	1	Yellow	St. Croix, Virgin Is.
Do. ...	51	51	18	11	41	11	22	12	3	Slight	1	do.	do. do.
Br—137 ...	49	49	17	11	47	13	21	12	2	do.	1	do.	do. do.
Do. ...	53	50	20	12	45	13	24	12	4	do.	1	do.	do. do.
Do. ...	48	51	20	11	45	13	20	12	3	do.	1	do.	do. do.
Do. ...	55	49	19	11	40	11	21	10	2	do.	1	do.	do. do.
Do. ...	44	51	21	12	38	11	22	12	4	—	1	do.	do. do.
Do. ...	47	49	16	11	43	12	20	12	2	Slight	1	do.	do. do.
Do. ...	49	50	18	11	55	11	25	12	2	—	1	do.	do. do.
Do. ...	50	50	20	14	48	12	27	10	2	Red	1	do.	do. do.
Do. ...	54	53	18	11	41	11	17	14	3	Slight	1	do.	do. do.
Do. ...	53	54	21	11	47	15	22	14	3	do.	1	do.	do. do.
Do. ...	48	53	23	11	43	12	20	12	2	Red	1	do.	do. do.
Do. ...	50	48	16	9	38	11	20	14	3	—	1	do.	do. do.
Br—134 ...	56	49	19	11	42	13	23	12	3	—	1	do.	do. do.
Br—135 ...	50	52	22	13	40	12	26	10	4	Slight	1	do.	do. do.
Do. ...	45	49	18	11	46	11	28	12	1	Red	1	do.	do. do.
Do. ...	51	48	18	11	54	11	23	12	2	do.	1	do.	do. do.
Do. ...	48	50	20	10	58	11	24	14	1	do.	2	do.	do. do.
Br— 136 ...	54	48	17	11	49	12	21	12	2	do.	1	do.	do. do.
Br—135 ...	48	54	19	10	40	12	21	14	2	Slight	2	do.	do. do.
Br—136 ...	56	48	17	10	54	11	28	12	2	Red	1	do.	do. do.
Do. ...	48	56	22	11	47	12	23	14	3	Slight	1	do.	do. do.
Br—135 ...	51	52	17	10	39	12	22	12	3	do.	1	do.	do. do.
		51	17	9	56	11	27	14	3	do.	1	do.	do. do.
Mean ...	50.5	50.7	19.0	11.0	45.7	11.8	22.9	12.4	2.5	—	1.0		

Early Caribbean may be of particular historical significance in that it was probably the type of maize first introduced into Europe by Hispanic explorers soon after the Discovery. Finan (1948) after carefully studying descriptions and illustrations of maize in the great herbals has concluded that the type first described by the herbalists (and probably first introduced into Europe from the New World) was not at all typical of the known Caribbean varieties. He cites particularly the absence of prop roots and the presence of husk-leaf blades, two characteristics which at the time of his writing were felt to be absent or at least uncommon in the West Indies. Early Caribbean is a type which fits almost perfectly the maize first described and illustrated by the herbalists. It also is similar in type and maturity to much of the modern flint corn grown at present in northern Italy and adjacent areas. The origin of this maize which is "Caribbean" in many characteristics has long puzzled the author because of its small plant size and early maturity, these two features being until recently unknown in the West Indies. Therefore the discovery of "Early Caribbean" in Martinique and St. Kitts supplies a reasonably satisfactory answer to a number of problems involving the origin and relationships of early season "Caribbean like" maize of modern Europe as well as that of the early herbalists.

Certain segregates of this race and of Haitian Yellow described previously are likewise of possible interest in connection with the history of the so-called "Eastern Complex" corns of eastern North America. These 8–10 rowed flints which comprise the earliest known prehistoric maize of eastern North America were widespread east of the Mississippi at the time of the Discovery. It has been generally assumed that the centre of distribution of this maize is Guatemala and adjacent Chiapas but the route by which it spread to North America has not been explained either to the satisfaction of botanists or ethnologists. According to Griffin (1949) a route through the Caribbean has been generally ruled out because of the differences in type between Caribbean corn and that of the south-east (Eastern Complex). While it is true that most corn of the Caribbean is quite different in type from that of the Eastern Complex the ears of certain segregates of Haitian Yellow and Early Caribbean are on the other hand very similar to the 8–10 row flints and flours of eastern United States. Plant types of the two differ primarily in the absence of tillers in the West Indian material. This bit of evidence is certainly not conclusive but it suggests that until archaeological evidence proves to the contrary, the Caribbean cannot be disregarded as a route of dispersal for Eastern Complex maize.

West Indian Semi-Dent—(Table 8, Plate 2)

This race of maize has apparently arisen from a series of selections out of accidental or intentional crosses between an extreme dent type and coastal tropical flint. It is probably of rather recent origin, yet in modern times it is widespread throughout the West Indies and is typical of much of the common corn of the area. Its apparent hybrid vigour resulting in high yield potential has obviously contributed to its widespread use.

TABLE VII. EAR MEASUREMENTS OF EARLY CARIBBEAN

Collectors Number	Basal Diameter mm.	Mid Ear Diameter mm.	Shank Diameter mm.	Kernel Width mm.	Kernel Thickness mm.	Kernel Length mm.	Ear Length cm.	Row Number	Denting	Pericarp Colour	Pointing	Endosperm Colour	Source
Br—147 ...	43	41	15	9	48	9	16	12	2	—	1	Yellow	Martinique
Do. ...	46	43	15	9	45	9	16	14	2	Red ...	1	do.	do.
Do. ...	43	40	13	9	39	9	14	12	2	—	1	do.	do.
Do. ...	49	46	18	10	48	9	15	12	1	Red ...	1	do.	do.
Do. ...	44	42	14	9	42	10	17	12	1	—	1	do.	do.
Br—146 ...	45	41	13	9	40	10	16	12	1	Red ...	1	do.	do.
Do. ...	44	41	13	9	50	10	19	12	1	do. ...	1	do.	do.
Do. ...	45	41	14	9	49	9	18	12	1	do. ...	1	do.	do.
Br—139 ...	46	44	15	9	48	10	20	14	1	do. ...	2	do.	do.
Do. ...	41	39	14	9	46	9	16	12	1	do. ...	1	do.	do.
Do. ...	46	40	16	10	37	10	16	10	1	do. ...	1	do.	do.
Do. ...	39	37	15	11	41	9	17	8	1	do. ...	1	do.	do.
Br—145 ...	46	44	15	10	43	10	20	12	1	do. ...	1	do.	do.
Br—143 ...	46	42	18	8	38	9	18	14	1	do. ...	1	do.	do.
Do. ...	45	43	13	9	43	10	19	14	1	do. ...	1	do.	do.
Do. ...	42	40	15	9	41	9	17	12	2	do. ...	1	do.	do.
Br—142 ...	42	38	16	9	48	9	19	12	1	—	1	do.	do.
Br—143 ...	39	34	14	10	45	9	19	8	1	Red ...	1	do.	do.
Do. ...	38	37	13	9	41	9	17	10	1	do. ...	2	do.	do.
Br—142 ...	41	39	16	9	46	9	18	12	1	do. ...	1	do.	do.
Do. ...	42	41	13	9	45	11	21	12	2	do. ...	1	do.	do.
Do. ...	42	40	16	9	42	10	23	12	2	do. ...	1	do.	do.
Br—141 ...	46	43	13	11	46	11	18	10	2	do. ...	1	do.	do.
Do. ...	49	40	19	11	49	9	21	10	0	do. ...	1	do.	do.
Mean ...	45	42	15	11	46	9	21	10	1	do. ...	1	do.	do.
	43.8	40.7	14.8	9.4	44.2	9.4	18.0	11.6	1.2	—	1.0		

The cylindrical or slightly tapered ears possess 12–16 rows of wide, slightly dented, deep yellow kernels. The kernels are 11–13 mm. in length, are usually without pointing and are conspicuously capped with a deposit of soft starch. The ears, although somewhat similar to those of Cylindrical Dent are longer, have fewer numbers of rows and are less dented. Cobs are white and are usually without the naked tip characteristic of certain of the other races. In comparison to the length of the kernels the pistillate glumes are quite short and are of soft texture.

The plants are of medium maturity (62 days to anthesis) and are approximately the same height as the Cylindrical Dents. They are without tillers and with the exception of occasional sun reds have very little anthocyanin colour. While the internodes above the ear are conspicuously short (Fig. 2) those below the ear often are considerably longer than the accompanying leaf sheaths. Although most plants have the ear placed high on the culm, they vary in this characteristic and one frequently encounters plants with relatively low ear placement.

The well exserted tassels consist of many long secondary branches attached at near right angles to the main axis. Most tassels exhibit no condensation, yet they vary considerably in this respect.

West Indian Semi-Dent is more common in Trinidad than in most of the other islands. Here it has been subjected to considerable selection by workers in the Department of Agriculture and several improved strains are now available which appear to be superior to the common sorts. In addition to Trinidad, typical specimens of the race may also be found in Cuba, Haiti, Dominica, Jamaica and the Dominican Republic. It is not unlikely that this particular hybrid combination has arisen independently in several places since both putative parents occur in a number of widely separated islands.

Summary of distribution of races

In addition to the information on distribution of races given in the foregoing paragraphs, it may be beneficial to local workers to have available a summary of types which are to be found in each of the islands included in the survey. The following supplement is provided for this purpose:

Cuba—Maiz Chandelle; Cylindrical Dent; Coastal Tropical Flint; Cuban Flint; West Indian Semi-Dent; a twelve to fourteen row pop corn which is thought to be modern and is excluded from the foregoing discussion; many recent selections; modern double-cross hybrids; intermediates between the recognized races.

Jamaica—Coastal Tropical Flint; West Indian Semi-Dent; much modern maize.

Haiti—Maiz Chandelle; Haitian Yellow; Cylindrical Dent; Coastal Tropical Flint; West Indian Semi-Dent; intermediate forms.

TABLE VIII. EAR MEASUREMENTS OF WEST INDIAN SEMI-DENT

Collectors Number	Basal Diameter mm.	Mid Ear Diameter mm.	Shank Diameter mm.	Kernel Width mm.	Kernel Thickness mm.	Kernel Length mm.	Ear Length cm.	Row Number	Denting	Pericarp Colour	Pointing	Endosperm Colour	Source
Br—110 ...	60	56	20	10	46	11	21	14	2	—	1	Yellow	Holguin, Cuba
Br—111 ...	62	51	22	9	44	12	19	16	2	—	1	do.	20 ki. W of Holguin, Cuba
Br—166 ...	51	55	17	10	46	13	23	14	2	—	1	Orange	Piarco, Trinidad
Br—161 ...	53	52	18	11	40	11	22	12	2	—	1	do.	St. Augustine, Trin.
Br—162 ...	55	54	18	10	46	11	17	14	2	—	1	do.	do. do.
Br—161 ...	53	51	17	10	44	11	25	14	2	—	1	do.	do. do.
Br—110 ...	58	52	22	10	39	12	20	14	2	—	1	Yellow	Holguin, Cuba
Br—161 ...	59	59	19	11	42	12	21	14	2	—	1	Orange	St. Augustine, Trin.
Br—153 ...	56	53	22	10	44	11	20	14	2	—	1	do.	Nr. S. Grande, Trin.
Br—158 ...	49	48	18	10	35	12	21	12	2	—	1	do.	5 mi. S of S. Grande, Trin.
Br—156 ...	52	51	21	11	41	13	25	12	2	—	1	do.	S. Grande, Trin.
Do. ...	52	49	13	9	40	12	19	14	2	—	1	do.	do. do.
Br—157 ...	51	51	16	10	43	12	20	14	2	—	1	do.	do. do.
Br—162 ...	54	52	20	10	41	12	21	14	2	—	1	do.	Nr. St. Aug., Trin.
Br—163 ...	50	49	17	9	38	12	20	14	2	—	1	do.	Nr. Piarco, Trin.
Br—166 ...	55	50	21	11	41	11	22	12	2	—	1	do.	do. do.
Br—157 ...	51	49	16	10	42	11	21	12	1	—	1	do.	S. Grande, Trin.
— ...	56	53	19	11	42	13	27	12	3	—	1	do.	Trinidad
— ...	57	53	20	10	37	13	23	14	2	—	1	do.	do.
— ...	54	52	20	10	44	11	23	12	2	—	1	do.	do.
— ...	60	59	20	10	40	12	21	14	2	—	1	do.	do.
— ...	56	53	19	10	43	12	21	14	2	—	1	do.	do.
Br—163 ...	54	51	15	9	48	11	21	14	2	—	1	do.	Central Trinidad
Do. ...	48	45	16	10	40	12	22	12	2	—	1	do.	do.
Do. ...	56	51	20	10	44	12	25	14	2	—	1	do.	do.
Mean ...	54.4	51.9	18.6	10.0	42.0	11.8	21.6	13.4	2.0	—	1.0		

Dominican Republic—Maiz Chandelle (dent form); Coastal Tropical Flint; West Indian Semi-Dent; many mixtures between the above and recently introduced types.

Puerto Rico—Coastal Tropical Flint; West Indian Semi-Dent; a great variety of recombinations between the above and recently introduced types.

St. Croix—St. Croix Long Ear.

St. Kitts—Early Caribbean, Coastal Tropical Flint.

Antigua—Coastal Tropical Flint; West Indian Semi-Dent; intermediates.

Dominica—Coastal Tropical Flint; West Indian Semi-Dent.

Martinique—Early Caribbean.

Trinidad—Maiz Chandelle; Cylindrical Dent; Coastal Tropical Flint; West Indian Semi-Dent; various intermediates between the above.

Possible Origin and Relationships of West Indian Maize

The dearth of prehistoric maize remains from the Greater and Lesser Antilles coupled with our still incomplete knowledge of the modern corns of the South American mainland renders it extremely difficult to arrive at any definite conclusions regarding the origin of present day West Indian maize. There are strong morphological resemblances between maize of the Antilles and that of both Middle and South America. From such resemblances one can develop provisional working hypotheses concerning the relationships of some of the West Indian material. In no case, however, is the evidence sufficiently clear to provide a final solution to this problem. These decisions must await additional evidence from the fields of anthropology and breeding.

Although the resemblances of West Indian maize to that of Middle and South America are evident there may remain some question as to the direction of stronger dispersal. It would seem, nevertheless, that the established antiquity of maize on the mainland and the reasonably well authenticated evidence for a South American origin of the Arawak and Carib is rather strong evidence for assuming that the direction of dispersal was from the mainland to the islands rather than the reverse.

In the following discussion each of the eight races described above will be treated separately.

Cuban Flint—This race whose distribution in the Antilles is limited to Cuba is probably a recent introduction from Argentina. Not only is it very similar in type to some of the modern maize of that country but it is also known that some twenty-five years ago maize from the Argentine was imported into Cuba in connection with a local corn improvement programme. That this type has survived in a relatively unaltered form is strongly indicated by the morphological evidence.

Cylindrical Dent—There seems little doubt that the phenomenon of denting in maize has spread from central Mexico in both a northern and southern direction. That the genes for denting in West Indian maize came originally

TABLE IX. AVERAGE PLANT CHARACTERISTICS OF EIGHT RACES OF WEST INDIAN MAIZE

	Days to Anthesis	Plant Height cm.	Length Husk Leaf Blades cm.	No. Secondary Tassel Branches	No. Tertiary Tassel Branches	Length Central Spike cm.	Diameter Culm mm.	Tassel Exsertion cm.	Angle of Tassel Branching*	Condensation
CUBAN FLINT	60	235	0	19.9	5.9	25.1	6.8	9.4	2.0	1.3
CYLINDRICAL DENT	63	301	0	24.0	8.7	26.0	6.6	4.9	2.3	1.5
HAITIAN YELLOW	74	299	8.3	21.5	8.7	26.5	7.8	3.9	2.7	1.0
COASTAL TROPICAL FLINT ...	68	289	0	25.2	9.3	26.5	6.9	3.9	2.1	1.2
MAIZ CHANDELLE	72	328	0	20.8	8.5	25.3	6.5	2.6	2.0	1.0
ST. CROIX LONG EAR	56	257	2.0	17.2	5.0	25.8	7.7	1.7	2.3	1.1
EARLY CARIBBEAN	48	193	1.0	15.4	5.0	26.0	5.7	5.5	1.9	1.0
WEST INDIAN SEMI-DENT ...	62	298	0	21.1	7.2	24.5	6.0	3.8	2.0	1.2

* 1—Drooping branches.
2—Branches at approximately right angles to main axis.
3—Branches upright.

from the same source is not at all unlikely. The Cylindrical Dents of Cuba and Haiti could have in prehistoric times come directly from Mexico as the archaeological resemblances between these regions are quite evident, (Rouse personal communication). However, the concentration of Cylindrical Dents in Trinidad is not so easily explained. As there are no known archaeological connections between Trinidad and Mexico and in the absence of a known source of extreme dents on the South American mainland, the concentration of this race in Trinidad, it would seem, is best explained as a result of dispersal from the Greater Antillean islands to the north. If Cylindrical Dent represents the principal source of genes for denting now widely distributed throughout the West Indies, it must have been in the area a long time to have infiltrated other races as completely as it has.

Haitian Yellow—A Middle American origin for Haitian Yellow is strongly suggested by the close morphological resemblance between this race and some of the common maize of Guatemala and adjacent Chiapas. The combination of ear characteristics possessed by Haitian Yellow could hardly, in view of our present knowledge, have come from any other source.

Coastal Tropical Flint—This race with a wide distribution throughout the West Indies has likely reached the area from the lowlands of eastern South America. Historical evidence, (Finan 1948), suggests that it was one of the types taken to Europe by early Hispanic explorers. It seems likely, therefore, that it was already in the West Indies at the time of historic contact, having probably been brought there and spread by the Arawak and Carib groups.

Maiz Chandelle—The origin of this race and the route by which it entered the West Indies is not at all clear. Some of its characteristics indicate a possible relationship to the primitive Dzit-Bacal—Nal-Tel complex, (Wellhausen et al 1951), of the Yucatan Peninsula while at the same time certain ears of this race are not unlike those of the flint form of Guarani maize from the Paraguay River basin previously described by Cutler (1942). The distribution of Maiz Chandelle and its association with conservative farmers of out of the way regions is indicative of its being an old, long established type. This argument has some support in the apparent relationship of Maiz Chandelle to the two mainland races referred to above, each of which is considered to be primitive.

St. Croix Long Ear—Maize morphologically similar to this race is found in the States of Chiapas, Vera Cruz and Gurrero in southern Mexico. It is there referred to by Wellhausen et al (1951) as "Olotillo" and is postulated to have arisen from crosses between teosinte and another Mexican race, Harinoso Flexible. A similar variety, Hickory King, whose origin undoubtedly is Mexican, has long been grown in southern United States from where it has been distributed to many tropical areas. There is a strong possibility, therefore, that St. Croix Long Ear, although of Mexican origin, might well have reached St. Croix in relatively recent times by way of southern United States. The political connection between St. Croix and the United States lends some support to this theory as does the absence of archaeological resemblances between Mexico and the Lesser Antilles.

Early Caribbean—In so far as the author is aware this race does not exhibit a close relationship to any known maize of either Central or South America, nor does it appear to be a recent introduction. Historical evidence, as was pointed out earlier, suggests it to be a remnant of one of the earliest types introduced into Europe and must, therefore, have been in the West Indies at the time of or soon following historic contact. Certain of its segregates do bear a resemblance to some maize of highland Guatemala whose ears are characterized by low numbers of rows of kernels, wide crescent seeds and enlarged bases. Yet there are distinct morphological differences between the average of this highland Guatemalan type and these segregates from Early Caribbean, and the apparent similarities between isolated specimens of the two may be of a superficial nature. Thus the relationships of this interesting race of maize must, for the present at least, remain a mystery.

West Indian Semi-Dent—There seems little doubt that West Indian Semi-Dents have evolved from crosses between Cylindrical Dent (or its more extreme progenitor) and Coastal Tropical Flint followed probably by accidental backcrosses to one or both putative parents. Although the proof for such an origin is lacking, pending the results from inbreeding, the morphological evidence is most convincing and the comparative vigour of the race is likewise indicative of a hybrid origin. Since the race itself as well as both putative parents are of wide distribution in the West Indies, it is probable that the postulated hybridizations have occurred repeatedly in rather widely separated areas.

Probable Usefulness of West Indian Varieties in Maize Improvement Programmes

On the basis of field observations and in the absence of performance trials it appears that certain segments of West Indian maize may provide a promising source of germ plasm for breeding purposes. It would also seem that the usefulness of this material is not confined to the Caribbean but may be found desirable in many tropical or semi-tropical areas where maize is grown, including the southern United States. Among the several apparently desirable gene combinations present in this material, one of the most striking is that affecting productivity. Certain races, West Indian Semi-Dent particularly, possess a vast amount of vigour and under favourable growing conditions produce yields which appear to be comparable to those of adapted double-cross hybrids. While this opinion is based on observation only, the observations include three Cuban hybrids, M11, M12 and M13, which were planted at intervals among the open pollinated cultures in Trinidad for the purpose of checking "appearance of yield". Much of the vigour of West Indian maize may well be due in part at least to the intermingling of several distinct races over rather long periods of time and may, therefore, represent hybrid vigour in the true sense. The situation is somewhat similar to that in the United States cornbelt where the high yielding open pollinated dent varieties which preceded hybrid maize and which provided the basic materials from which hybrids have been developed were themselves rather recent hybridization products of at least two distinct races.

The West Indian Semi-Dents appear to be the most productive corns of the area. Typical samples of these are represented by the collection numbers listed in Table 8. Other races which appear to have better than average yielding capacity are Cylindrical Dent, Coastal Tropical Flint and St. Croix Long Ear.

In addition to yield, other important agronomic characteristics of West Indian maize include earliness, absence of tillers, good husk coverage, high percentage of carotene and perhaps some resistance to a species of rust, *Puccinia polysora*. Early maturity in combination with absence of tillers and adaptation to a tropical environment is found in the race Early Caribbean. This particular combination of characters is desirable in some semi-tropical areas yet it is one not frequently encountered in maize. Long tight husks, although characteristic of most West Indian maize, are accentuated in Haitian Yellow, Maiz Chandelle and Cuban Flint. In contrast, loose husks which tend to open at maturity and which under certain conditions are considered a desirable characteristic, are found in Early Caribbean and St. Croix Long Ear. A deep yellow endosperm colour associated probably with high carotene content, is most pronounced in Cuban Flint and West Indian Semi-Dent.

A species of rust, *Puccinia polysora*, that has in recent years caused serious reduction in yields of maize in West Africa, is also present in the West Indies. It was observed in all the author's experimental maize plots in Trinidad in 1952–53 and was particularly damaging to North American inbreds and hybrids as well as to some West Indian varieties. Certain collections, on the other hand, were almost free of rust. Whether these represent escapes or some degree of resistance is not known since infection was by natural means only but in any case it appears these cultures might merit additional observation by workers interested in rust resistance. In the experimental plots in Trinidad, those cultures exhibiting little or no rust infection were Br 170, 172, 175, 164, 162, 157 and 130.

Summary

The importance of maize classification in relation to its improvement is discussed with particular reference to West Indian varieties.

A short history of the recognized ethnic groups of the Antilles is presented and related to the origin of maize of the area.

Collections from eleven West Indian islands have provided the material for a study of the variability and relationships of maize of the Caribbean. In spite of extreme overall variability of this material, natural relationships between varieties and in some cases distinct geographical distributions have made possible the recognition of eight provisional races. These have been given common descriptive names as follows:

(1) Cuban Flint, (2) Cylindrical Flint, (3) Haitian Yellow, (4) Coastal Tropical Flint, (5) Maiz Chandelle, (6) St. Croix Long Ear, (7) Early Caribbean, (8) West Indian Semi-Dent.

Present distributions and detailed descriptions are given for each race. It is suggested that five of these represent old indigenous types while the remaining three are probably recent introductions.

The possible origin of each of the West Indian races and its relationship to maize of the mainland is discussed. There is considerable evidence to indicate that central Mexico, the Yucatan Peninsula and coastal areas of eastern South America have each contributed to the evolution of maize of these islands.

Probable usefulness of West Indian varieties in modern maize improvement schemes is discussed. It is pointed out that the unusually high yielding capacity as well as other desirable agronomic characteristics of some of the races render them a potentially valuable source of breeding material for tropical and semi-tropical areas.

Acknowledgements

It is a pleasure to acknowledge the aid of institutions and individuals in the West Indies whose co-operation has helped greatly in the execution of this work. Through the kindness of the administration of the Imperial College of Tropical Agriculture, Trinidad, the author was permitted to spend the academic year 1952–53 as a guest of that institution where he was provided with excellent field and laboratory facilities. Particular thanks are due the staff of the Department of Botany and Plant Pathology of I.C.T.A. for their ready co-operation. For the provision of transport and for their help in making field collections the author gratefully acknowledges the assistance of Mr. C. G. del Valle, Estación Experimental de Agronomica, Santiago de las Vegas, Cuba; Mr. Claude Preval, Directeur General de l'Agriculture, Damien, Haiti; Mr. George Mottard, Directeur des Services Agricoles de la Martinique and Mr. L. Johnson, Department of Agriculture, Trinidad.

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(*Received for publication, May,* 1953)

THE EFFECT OF CULTURAL TREATMENTS ON THE FROST INJURY AND GROWTH OF SANSEVIERIA IN SOUTH FLORIDA[1]

By

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The genus *Sansevieria* is indigenous to tropical Africa (Brown 1951), but several species have been introduced and become naturalized in the sub-tropic of South Florida (Dodge 1893; Robinson and Joyner 1948). Cultural studies on the cultivation of the plant for fibre at Boynton, Florida indicated that *S. thyrsiflora* Thunb. (*S. guineensis* Willd.) could be readily propagated by leaf cuttings or young plants and that mulch, cover crops and commercial fertilizers greatly improved the rate of growth (Bair 1945; Joyner and Gangstad 1951). While most species are readily damaged by frost in South Florida, *S. trifasciata* Prain has shown some tolerance to cold and considerable potentiality for production of fibre (Gangstad, Joyner, and Seale 1951; Robinson and Joyner 1948).

The effects of some cultural treatments on the frost injury and growth of sansevieria in South Florida are presented in this paper.

Frost Injury of Sansevieria

The frost injury of *S. thyrsiflora* Thunb., *S. longiflora* Sims, *S. trifasciata* Prain and *S. trifasciata* var. *laurentii* N.E.B., approximately 1 year old are given in Table 1 as the average per cent. of frost injured leaf to total length of leaf of 10 leaves per plot of 3 replications at 5 locations in South Florida for the winter season of 1950–51. These plots were kept relatively free of weeds by hand weeding, and commercial fertilizer was applied according to the soil requirements.

These general observations indicate that the species of sansevieria studied are all subject to frost injury and that none of the locations observed are completely frost free.

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[1] Studies of the Division of Cotton and Other Fibre Crops and Diseases, Bureau of Plant Industry, Soils and Agricultural Engineering, Agricultural Research Administration, U. S. Department of Agriculture, with the Division of Agricultural Engineering and Everglades Experiment Station co-operating. Published with the approval of the Chief of the Bureau of Plant Industry, Soils and Agricultural Engineering and the Director of the Florida Everglades Experiment Station.

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The species differed in their tolerance to cold. *S. trifasciata* var. *laurentii* was least affected by cold. *S. trifasciata* and *S. longiflora* were not as seriously injured by cold as *S. thyrsiflora.*

TABLE I. Frost Injury of Experimental Plots of Four Species of *Sansevieria* Approximately One Year Old as the Average Percentage of the Frozen Leaf Tip to Total Length of Leaf for the Winter Season of 1950–51 at Five Locations in South Florida.

Location	*thyrsi-flora*	*longi-flora*	*trifas-ciata*	*laurentii*	Average
Belle Glade (peat soil) 13.5 hours below 32 °F.	98.1	92.5	96.0	95.7	95.5
Fort Myers (mucky sand) 4.5 hours below 32 °F.	64.3	55.0	59.6	28.9	49.5
Indiantown (light sand) 0.5 hours below 32 °F.	51.2	16.2	25.2	8.1	20.1
Boynton (light sand) 1.6 hours below 32 ° F.	45.8	2.8	2.7	0.3	10.3
Fort Lauderdale (mucky sand) 0.0 hours below 32 ° F.	11.8	4.9	3.1	1.6	5.3
Average	54.2	34.2	35.3	26.9	

The injury from cold was most severe on the peat soil at Belle Glade. Sandy locations near the coast were not as seriously affected.

CULTURAL TREATMENT OF LEAF CUTTINGS

The effects of some cultural treatments on leaf cuttings of *S. trifasciata* planted in a randomized block experiment of three replicates with 6 x 9 foot plots on Davie fine sand at Port Mayaca, Florida are summarized in Table 2.

It is found that mulching, manuring and cover crop treatments did not significantly affect the mortality of leaf cuttings three months after planting. Mulching with wood pulp significantly increased the number of frosted cuttings, four months after planting (January, 1951). Weed growth within the row was significantly increased by covering the surface of the soil with aluminium foil. The number of plants, nine months after planting, did not differ significantly in any of the treatments.

While legume cover crops can be used to improve soil fertility, most legumes are relatively short-lived and do not provide adequate cover for weed control during the whole season. Mulching treatments tend to increase the hazard of frost to the top growth by reducing radiation from the soil during a period of cold, but the number of plants per area is not greatly affected.

TABLE 2. Summary of Effects of Some Cultural Treatments of Leaf Cuttings of *Sansevieria trifasciata* Prain on Davie Fine Sand at Port Mayaca, Florida. August, 1950–51

Cultural Treatment	"Live" Cuttings per Plot (3 Mths After Planting)	Frost Injured Cuttings per Plot (4 Mths After Planting)	Weed Growth Oz. Green Wt. per Plot (5 Months After Planting)	*Sansevieria* Plants per Plot (9 Mths After Planting)
Control—No fertilizer	123	24	52.0	105
Control—Plus 40 lb./acre N (Uramon)	112	40	42.0	103
Cover with aluminium foil plus 40 lb./acre N (Uramon) ...	109	32	80.7	113
Cover with Seminole cowpeas ...	109	33	22.3	102
Mulch with wood pulp... ...	103	89	54.7	80
Mulch with chicken manure ...	107	24	66.3	92
LSD .05	NS	17	20.4	NS
LSD .01	—	24	29.0	—

CULTURAL TREATMENTS OF WHOLE PLANTS

The growth and frost injury of a two-year stand of *S. trifasciata* on Leon fine sand at Boynton, Florida in a randomized block experiment of two replicates with 12 x 15 foot plots for a series of cultural treatments are given in Table 3. All treatments significantly increased plant height over control. The cover crop of hairy indigo and the mulch of chicken manure greatly increased the growth in height.

The unfertilized control was severely damaged by frost, but the fertilized, cultivated control and the burlap cover plots were not seriously injured. It is observed that cover crops were only partially effective in controlling frost damage. Where the canopy of the cover crop was above the sansevieria, there was little or no injury, but where the vegetative growth was below the leaf tips, the leaves were badly frozen.

It is difficult to obtain a regular uniform cover crop for frost protection and the débris of old stems and vines is objectionable for harvesting of the sansevieria. Cover crops are also difficult or impossible to plant in an established stand of sansevieria. The advantage of mulching and cover crop treatments for growth of sansevieria is largely lost by increased danger of frost. If a variety or strain of sansevieria could be obtained which would give a mature

growth of fibre within the season, mulching treatments in particular, might prove very beneficial.

TABLE 3. Growth and Frost Injury of Cultural Treatments of a Two Year Stand of *Sansevieria trifasciata* Prain on Leon Fine Sand at Boynton, Florida. 1950–51.

Cultural Treatment	Average Plant Height	Leaves per Sq. Ft.	Frost Injury
Control—No fertilizer—weedy	14	23	Severe
Control—1,000 lb./acre 12–8–8 NPK—cultivated	25	22	Slight
Control—1,000 lb./acre 12–8–8 NPK—burlap cover	29	20	Nil
Cowpea cover crop—Not fertilized ...	29	23	Irregular
Velvet bean cover—Not fertilized ...	31	28	Irregular
Hairy indigo cover—Not fertilized ...	38	26	Irregular
Cow manure mulch—Natural fertilizer ...	27	31	Irregular
Chicken manure mulch—Natural fertilizer	37	28	Irregular
LSD .05	12.5	NS	—
LSD .01	18.5	—	—

In the course of this study, it has been observed that heavily fertilized plots are often severely damaged when they are badly infested with weeds that do not form a protective cover. Clean cultivation will increase radiation from the soil, and is considered a practical measure of frost protection.

FERTILITY TREATMENTS OF WHOLE PLANTS

The percentage frost injury as related to NPK treatments in a 3 x 3 x 3 factorial experiment on a 2-year stand of *S. trifasciata* on Leon fine sand is given in Table 4. It is found that the N_2K_2 levels of fertilization greatly reduced frost injury, but application of phosphorus had very little effect. The reduction in frost injury is directly related to the growth of the sansevieria under these treatments, and it is assumed that the effects are largely related to the proper nutritional balance necessary for good growth. However, the density of stand or other factors such as the electrolytic concentration of solutions in the plant tissue may be more directly concerned.

In a similar factorial experiment on Everglades peat soil at Belle Glade, Florida, the sansevieria was completely frosted in 1950–51, there was little or no injury in 1951–52 and there was a range of 49 to 66 per cent. frost injury

in 1952–53. While the potash treatment significantly reduced frost injury, nitrogen and phosphorus had no significant effect.

TABLE 4. Percentage Frost Injury of Two-Year Stand of *Sansevieria trifasciata* Prain on Leon Fine Sand at Boynton, Florida as Related to Fertility Treatments in a 3 x 3 x 3 NPK Factorial. 1949–50.

Pounds per acre N	Pounds per acre P_2O_5	Pounds per acre K_2O 0	50	100
0	0	65.0	58.1	33.4
	50	70.4	62.2	58.6
	100	48.1	66.3	64.9
75	0	56.0	38.7	42.3
	50	39.6	57.7	32.3
	100	57.6	54.3	36.2
150	0	31.8	46.3	9.2
	50	55.9	42.3	18.1
	100	67.3	10.9	19.2
Summary of NK Effects*				
		K_2O		
	N	0	50	100
	0	61.2	62.2	53.3
	75	54.0	50.5	36.9
	150	51.6	33.1	12.1

* Percentage frost injury calculated as percentage of frost injured tip of leaf to total length of leaf. Significance of treatment effects for direct measurements is given in Table 5.

It is assumed that the fertility treatments were more effective on the sandy soils than on the peat soil because of the greater protective radiation from the sandy soil and shorter duration of cold.

The mean height of the sansevieria leaves for the main effects of the NPK factorial at Boynton after frost in January, 1951 and before frost in December 1951 are given in Table 5 for frozen and unfrozen leaves. It may be seen from this data that leaves frosted in 1950, regardless of treatments, did not resume growth. However, the average height of unfrozen leaves before frost in 1951 was considerably greater than the average height of the stand in 1950. The results indicate that the leaves just below the vegetative canopy in 1950, continued growth in 1951. Proper fertilization according to the soil and plant requirement is considered a practical measure of frost protection for the growth of sansevieria.

TABLE 5. Average Height of Leaves of a Two Year Stand of *Sansevieria trifasciata* on Leon Fine Sand at Boynton, Florida for the Main Effects of a 3 x 3 x 3 NPK Factorial, After Frost Injury in 1950 and Before Frost in 1951

	AVERAGE HEIGHT OF FROZEN LEAVES		
	Pounds per acre		
N	0	75	150
1950 ...	6.9	10.4	15.8**
1951 ...	6.0	9.9	14.1**
P_2O_5	0	50	100
1950 ...	11.7	10.6	10.8
1951 ...	10.3	8.9	10.7
K_2O	0	50	100
1950 ...	7.9	10.8	14.3**
1951 ...	6.8	10.6	12.6**

LSD .05 (1950) 2.6; (1951) 2.4
LSD .01 (1950) 3.6; (1951) 3.2

	AVERAGE HEIGHT OF UNFROZEN LEAVES		
	Pounds per acre		
N	0	75	150
1950 ...	17.7	20.2	22.6**
1951 ...	15.1	21.4	26.8**
P_2O_5	0	50	100
1950 ...	20.5	19.8	20.1
1951 ...	21.1	21.5	20.7
K_2O	0	50	100
1950 ...	18.3	20.3	21.9**
1951 ...	16.9	22.2	24.2**

LSD .05 (1950) 0.4; (1951) 1.9
LSD .01 (1950) 0.6; (1951) 2.6

**Highly significant

SUMMARY

Sansevieria thyrsiflora Thunb., *S. longiflora* Sims, *S. trifasciata* Prain and *S. trifasciata* var. *laurentii* N. E. B. have been observed for frost injury at several locations in South Florida. The species *S. trifasciata* var. *laurentii* N. E. B. was least affected by cold.

The cold tolerance of *S. trifasciata* Prain, a good fibre type, was improved by clean cultivation and proper fertilization. These cultural treatments were more effective on sandy soil at Boynton than on the peat soil at Belle Glade.

The number of plants per square foot was not significantly affected by frost injury of the above-ground portion of the plant. Leaves that were injured by cold did not resume growth, but the unfrozen leaves continued to grow and the general height of the stand increased.

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(*Received for publication, July,* 1953)

PRACTICAL ASPECTS OF CHEMICAL WEED CONTROL IN SUGAR-CANE FIELDS IN MAURITIUS

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Introduction

Mauritius is mainly a sugar-producing island. Of the 199,000 acres of agricultural land under cultivation ,176,400 acres, representing approximately 38 per cent. of the total area of the island, are devoted to sugar-cane. The average sugar production is 445,000 metric tons per annum.

During the war years 27½ per cent. of the cane area was compulsorily placed under food crops. Owing to the fact that most of the foodcrops grown could not shade the soil as heavily as the canes generally do, it followed that encroachment of weeds upon arable land soon became a problem of great concern to sugar-cane growers. A weed survey was carried out in 1944 by the Sugar-cane Research Station with a view to assessing the economic importance of the weed population. From an economic viewpoint hand-weeding could not, at that time, solve the problem of weed invasion of cane fields.

In 1945, chemical weed control was for the first time seriously considered and exploratory work in that field began in the same year. Sodium chlorate, copper chloride and di-nitro-ortho-cresol derivatives were amongst the first weed killers to be tried on some of the noxious weeds. In 1946, chemical weed control had become a major line of research in the Sugar-cane Research Station. A series of investigations carried out by Dr. H. Evans, during the years 1946–1948, produced valuable information on a wide range of problems on the weed flora and its control. It was established, for example, that the umbelliferous weed, *Hydrocotyle bonariensis*, which infested hundreds of acres of cane land could be easily eradicated by one or two applications of Methoxone or Sodium 2,4-D while the composite, *Artemisia vulgaris*, relatively resistant to the above weed killers, was susceptible to sodium chlorate treatment.

Since 1948 steady progress has been maintained on the chemical control of weeds in cane fields. The present paper deals in a summarized form only, with the results of experiments carried out in different localities of the island with certain weed killers.

Materials and Methods

The weed killers tried in these experiments were:—

Agroxone—2-methyl-4-chlorophenoxyacetic acid—MCPA—sodium salt.

Fernoxone—2,4–dichlorophenoxyacetic acid—2,4-D—sodium salt.

Ialine—2,4–dichlorophenoxyacetic acid—2,4-D—tri-ethanol amine salt.

Dicotox—2,4-dichlorophenoxyacetic acid—2,4-D—ethyl ester.

Shell D—2,4-dichlorophenoxyacetic acid—2,4-D—iso-propyl ester.

Weedone LV IV—2,4-dichlorophenoxyacetic acid—2,4-D—butoxy-ethanol ester.

The dosages used varied from two to four pounds acid per acre for Agroxone, Fernoxone and Ialine, and from half to three pounds acid per acre for Dicotox, Shell D and Weedone. All applications were made with a knapsack sprayer, using 60 gallons of water per acre.

All trials were laid out statistically, with four replicates in each treatment. Weed assessment was made by the Frequency—Abundance method.

Pre-emergence Treatment

The efficiency of the pre-emergence treatment was found to be greatly influenced by the surface condition of the soil. The best results were obtained when the soil was worked into a fine tilth, presumably because the penetration of the herbicide in the soil layers occurs more readily, thus increasing the possibility of contact between the toxic material and the germinating weed seeds. In experiments where clods of soil were purposely left in the field, all treated plots became weed infested at the same rate as the controls.

Of the weed killers tested, Agroxone at the rate of three to four pounds acid per acre was found to be the best treatment. Treated plots remained weed-free for a period varying from six weeks to three months, according to the rainfall of the locality. As a rule, in super-humid regions which are subjected to a rainfall exceeding 100 inches per annum, treated plots became infested with weeds more rapidly than in humid regions, that is, those receiving between 50 and 100 inches annually. The sodium and amine salts of 2,4-D were found to be the second best treatments. On a comparative basis, the esters were found relatively less effective than the other treatments. It was also recorded that at dosages higher than one pound acid per acre for Dicotox and one-and-a-half pounds acid per acre for Shell D and Weedone, these esters caused a marked retardation in cane growth. This was evident about a fortnight after their application from a severe scorching of young cane leaves, development of necrotic areas on older ones and occasional death of young shoots. It was also observed that Agroxone, and sodium and amine salts of 2,4-D occasionally cause temporary injury to young cane shoots, particularly during the early phases of development from the setts, when growth may be retarded during a period of ten to twenty days.

Perennial broad-leaved weeds and grasses were found difficult to control by the pre-emergence treatment. In cane fields where local societies of perennial weeds such as *Cyperus rotundus*, *Oxalis corymbosa*, *Cynodon dactylon* and *Phalaris arundinacea* occurred, pre-emergence spraying resulted in a marked increase in the population of these weeds probably due to the absence of competition from annual weeds.

Post-Emergence Treatment

In all experiments in which post-emergence treatment was studied, esters were found more efficient than Agroxone and sodium 2,4-D treatments, at the dosages mentioned previously ; their killing action extended over a wider range of weed species than the other herbicides under test. When dosages higher than one pound acid per acre for Dicotox and one-and-a-half pounds acid per acre for Shell D and Weedone were used, very good results were obtained on the general weed population but such amounts were found to be detrimental to cane growth. The amine salt of 2, 4-D gave a good control of *Cyperus rotundus* but, on the other hand, did not prove more efficient than the esters in the control of other weeds.

The degree of kill by the post-emergence method was on the whole very variable and it was observed that individual weed species showed a differential response to herbicidal action at different stages of their development. Thus, *Solanum nigrum*, a common cane field weed, was found to be fairly susceptible at the seedling and flowering stages but relatively resistant at the pre-flowering stage.

Conclusions

The results obtained in this series of experiments show that pre-emergence treatment is the method more likely to give satisfactory results in practically all localities of the island. In the selection of a weed killer for this practice preference should be given, first to the sodium salt of MCPA and then to the sodium and amine salts of 2,4-D. Rain was not found to be a factor limiting the application of this method. If rain fell during or following a pre-emergence spraying practically no difference was observed on the results obtained, provided extremely heavy showers were not experienced on the day of the spraying or the days following it.

On the other hand, in cane fields where perennial weeds form the dominant population, post-emergence treatment was found to give the more satisfactory results. In such cases, it was observed that pre-emergence spraying should only be carried out after the perennials had been completely eradicated by successive post-emergence sprayings.

It was also found that in fields to be planted, post-emergence spraying one to three months before cultivation reduced the intensity of weed infestation at planting time and later when the canes had become established. The best post-emergence treatments were found to be : sodium chlorate on a mixed population of annuals and perennials, sodium salt of TCA in cases of specific

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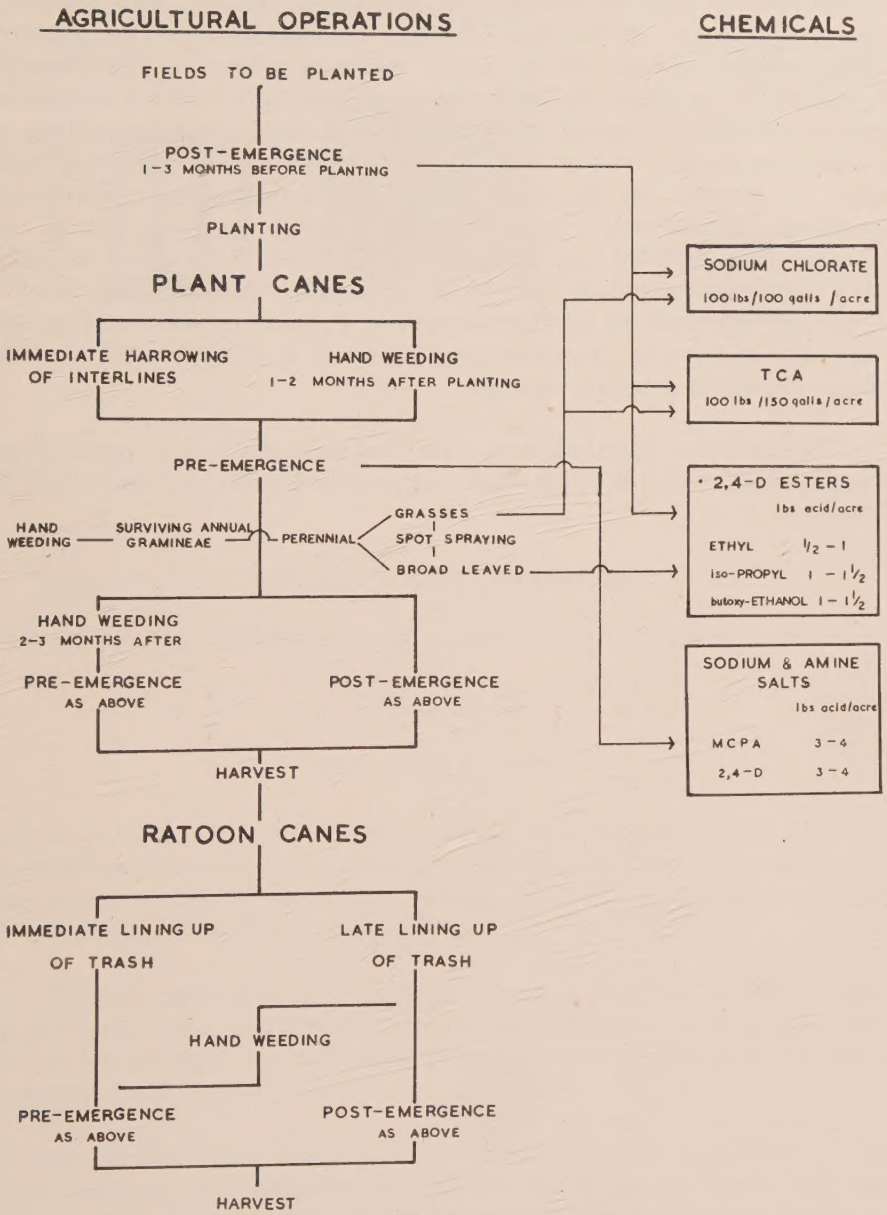

FIG. 1.

dominance by grasses such as *Cynodon dactylon*, *Imperata cylindrica* and *Ischaemum aristatum* ; amine salt of 2,4-D particularly against *Cyperus rotundus* and finally esters of 2,4-D on communities of perennial broad-leaved weeds.

Post-emergence treatment however, may be limited by a variety of factors such as stage of development, spray concentration and prevailing climatic conditions. It has been observed, for example, that the common weeds *Solanum nigrum*, *Bidens pilosa*, *Ageratum conyzoides* and *Plantago lanceolata* may be completely eradicated by a single application of a hormone type of herbicide, if spraying is carried out when they are at the seedling or pre-flowering stages. The same species show considerable resistance at other stages of growth. On the other hand, of the two species, *Hydrocotyle bonariensis* and *Ambrosia artemisiifolia*, the former is very susceptible to low concentrations of MCPA and derivatives of 2,4-D, while to destroy the latter much higher concentrations have to be used. Finally, in the high rainfall zone which represents an approximate area of 40,000 acres and has about 200 rainy days per annum, post-emergence spraying is often delayed for long periods owing to frequent showers.

The relation of chemical weed control to cane cultivation operations as practised in Mauritius is summarized and presented in diagrammatic form in figure 1.

(*Received for publication, August*, 1953)